NASA Tech Briefs

THE DIGEST OF NEW TECHNOLOGY

Official Publication of the National Aeronautics and Space Administration

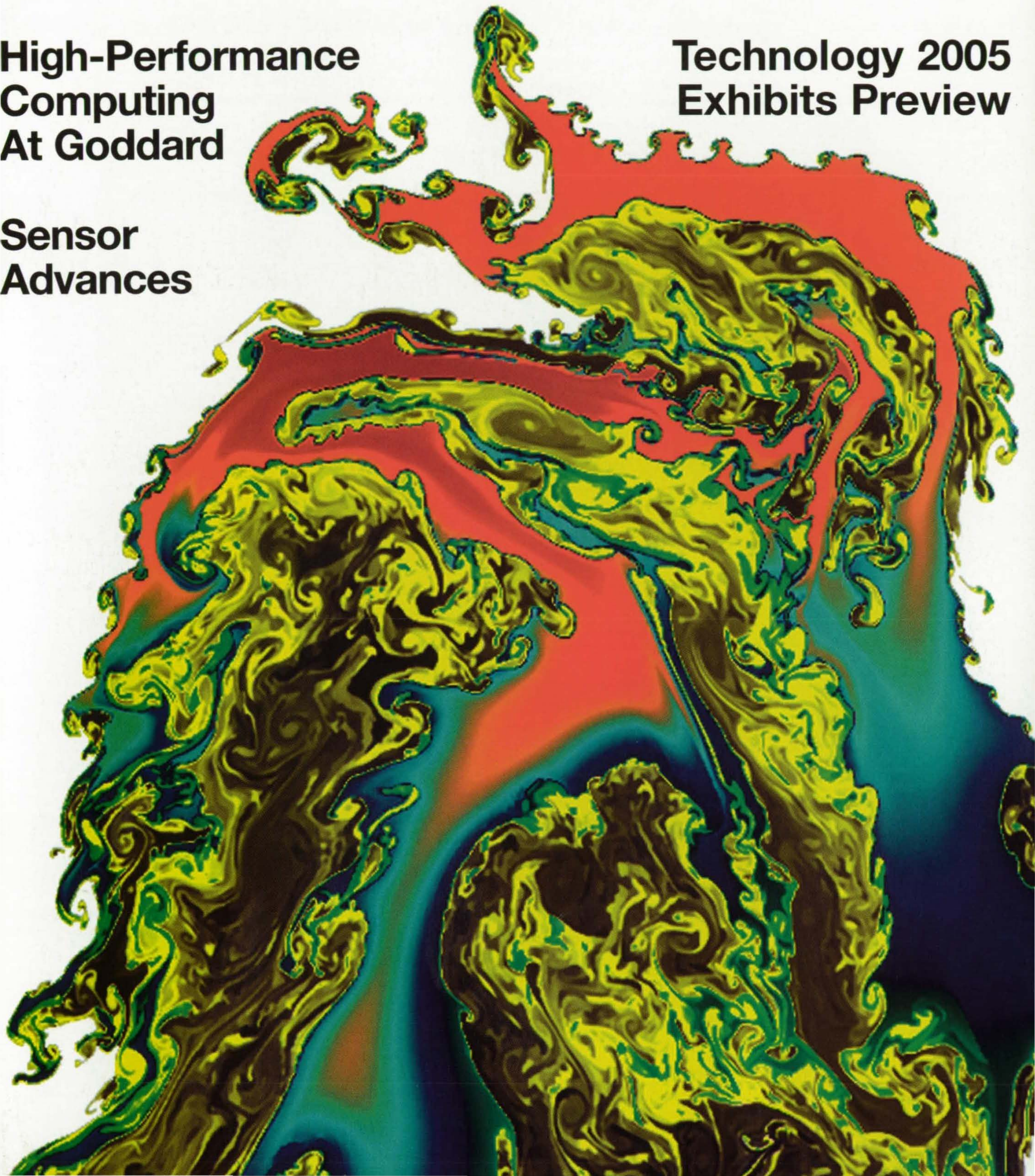
September 1995 Vol.19 No.9

Transferring Engineering Technology to Over 200,000 Qualified Readers Throughout Industry and Government

High-Performance Computing At Goddard

Technology 2005 Exhibits Preview

Sensor Advances



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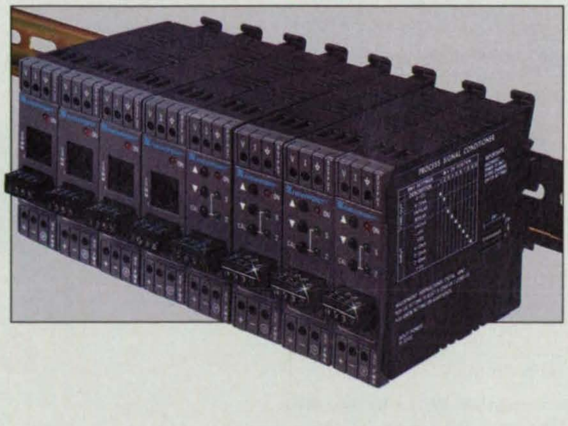

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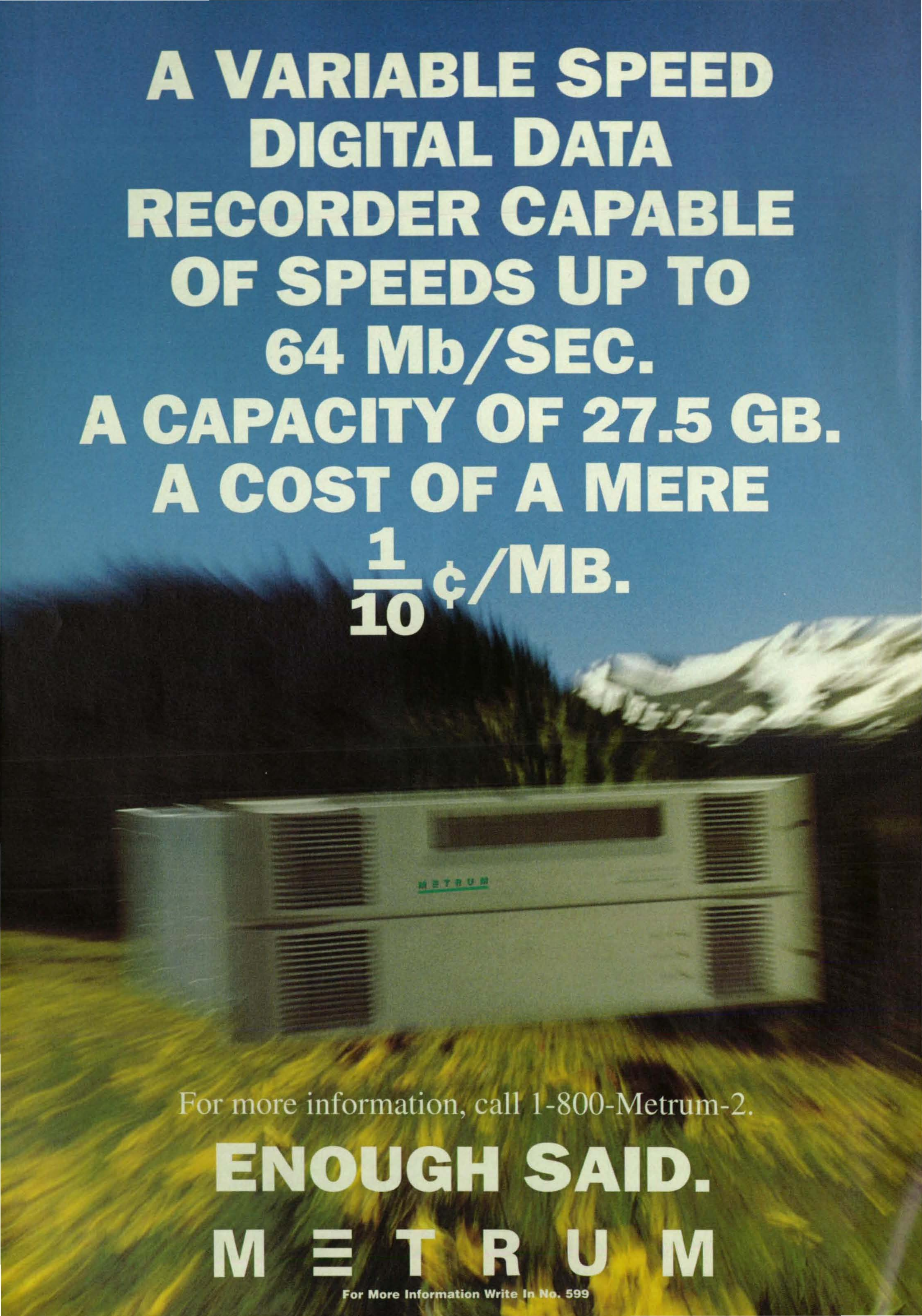
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Contents

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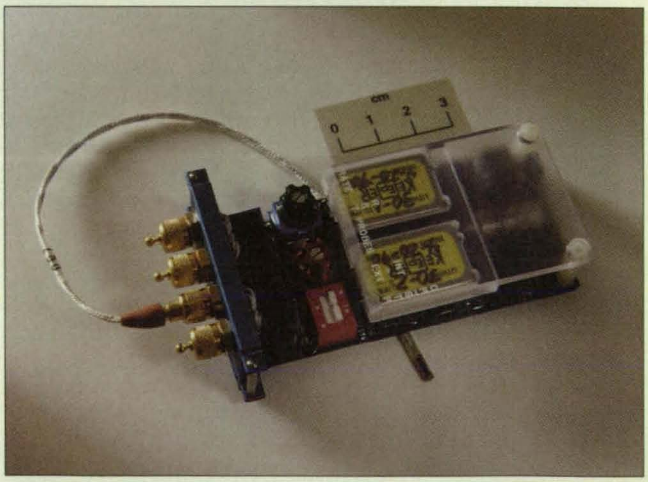
FEATURES

TECHNICAL SECTION

(continued on page 10)



A lightweight (135-gram) electronic ambient-temperature recorder developed at Ames Research Center logs up to 342 days' data in its internal memory for later readout or display on a computer. Designed for measuring instrument temperatures and for life-science experiments on spacecraft and high-altitude aircraft, the recorder has potential terrestrial applications such as recording temperatures of perishable items during transport. Turn to the brief on page 58.

Photo courtesy of Ames Research Center

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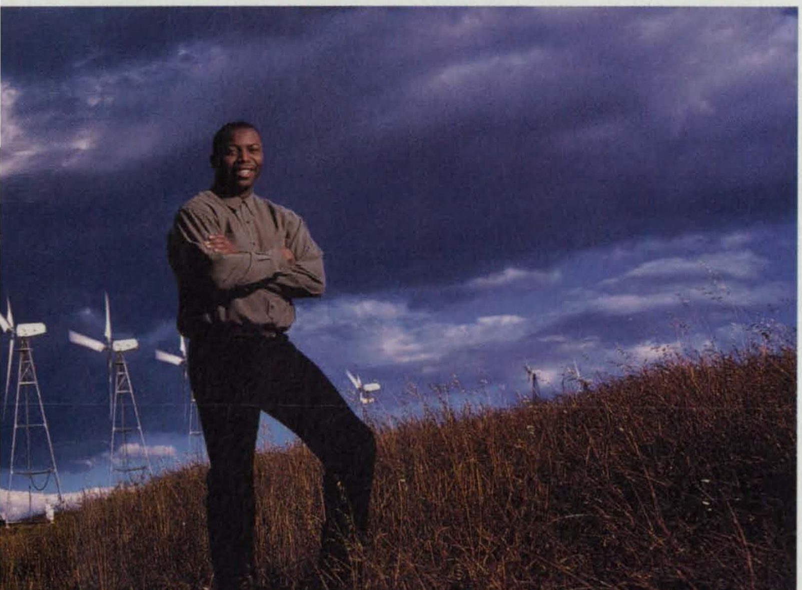
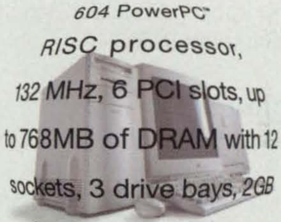
And it occurs to you:



It's not how powerful the computer is.



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Contents *(continued)*

DEPARTMENTS

On the Cover:

The 16,384-processor MasPar MP-2 at Goddard Space Flight Center took 60 hours and ran 4 gigaFLOPS to simulate a Rayleigh-Taylor Instability, in which a denser fluid forms fingers that drop into a lighter fluid below it, which in turn bubbles up. (The photo is oriented so the modeled fluid is flowing "upward".) The phenomena occurs in situations such as supernovae, laser fusion, and coffee with cream. For more on Goddard, see the Resource Report on page 22.

Photo courtesy of Goddard Space Flight Center

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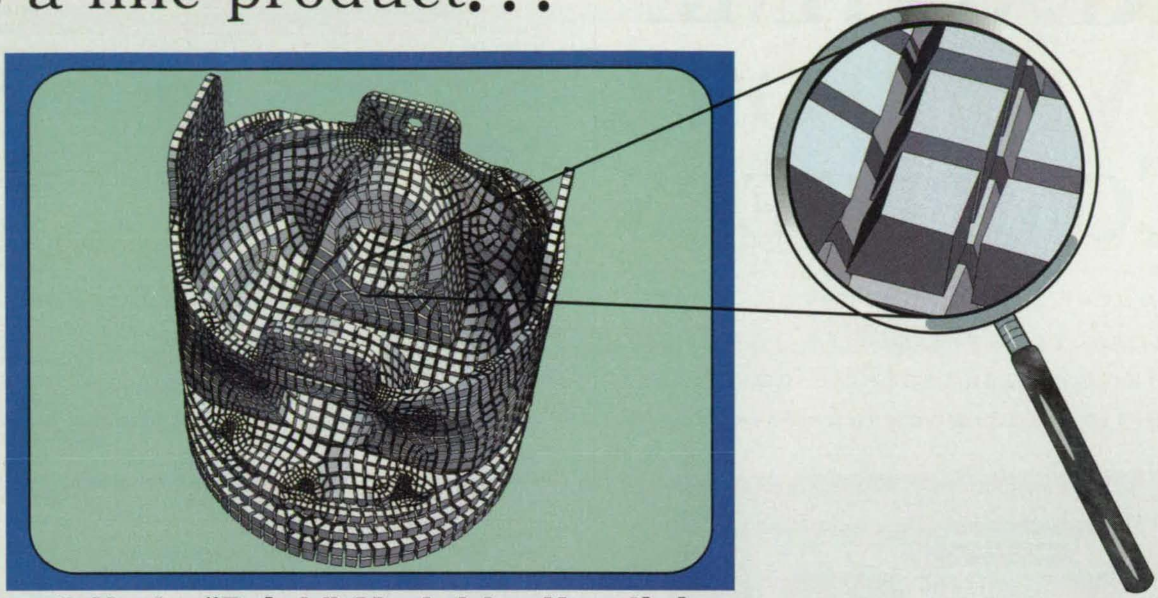

8-Node "Brick" Model by Houdini

Houdini meshed this CAD solid model directly from Pro/ENGINEER® with 8-node "brick" finite elements. Note local mesh refinement.

...Now, add Houdini™ to automatically convert your CAD solid models into 8-node "brick" finite element meshes.

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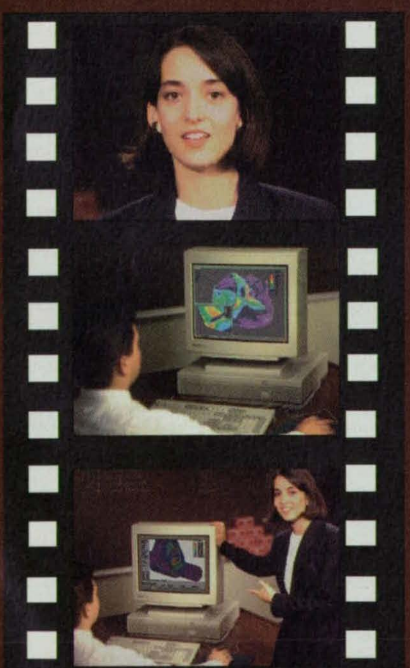

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NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC). We encourage all businesses with technical needs to contact the appropriate organizations for more information. For those who have access to the Internet, general information can be accessed with Mosaic software on the NASA Commercial Technology Home Page at URL: http://nctn.oact.hq.nasa.gov. Instructions regarding how to acquire the free Mosaic software can be obtained by sending an e-mail request to: innovation@oact.hq.nasa.gov.

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Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Syed Shariq
(415) 604-0753
syed_shariq@qmgate.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3119
duke@louie.dfrf.nasa.gov

Goddard Space Flight Center
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(301) 286-5810
galcorn@gsfc-mail.nasa.gov

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Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Wayne Schober
(818) 354-2240
wayne.r.schober@jpl.nasa.gov

Johnson Space Center
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Hank Davis
(713) 483-0474
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Charlie Blankenship
(804) 864-6005
c.p.blankenship@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Walter Kim
(216) 433-3742
wskim@lims01.lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Harry Craft
(800) USA-NASA
susan.van.ark@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
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ajohnson@ssc.nasa.gov

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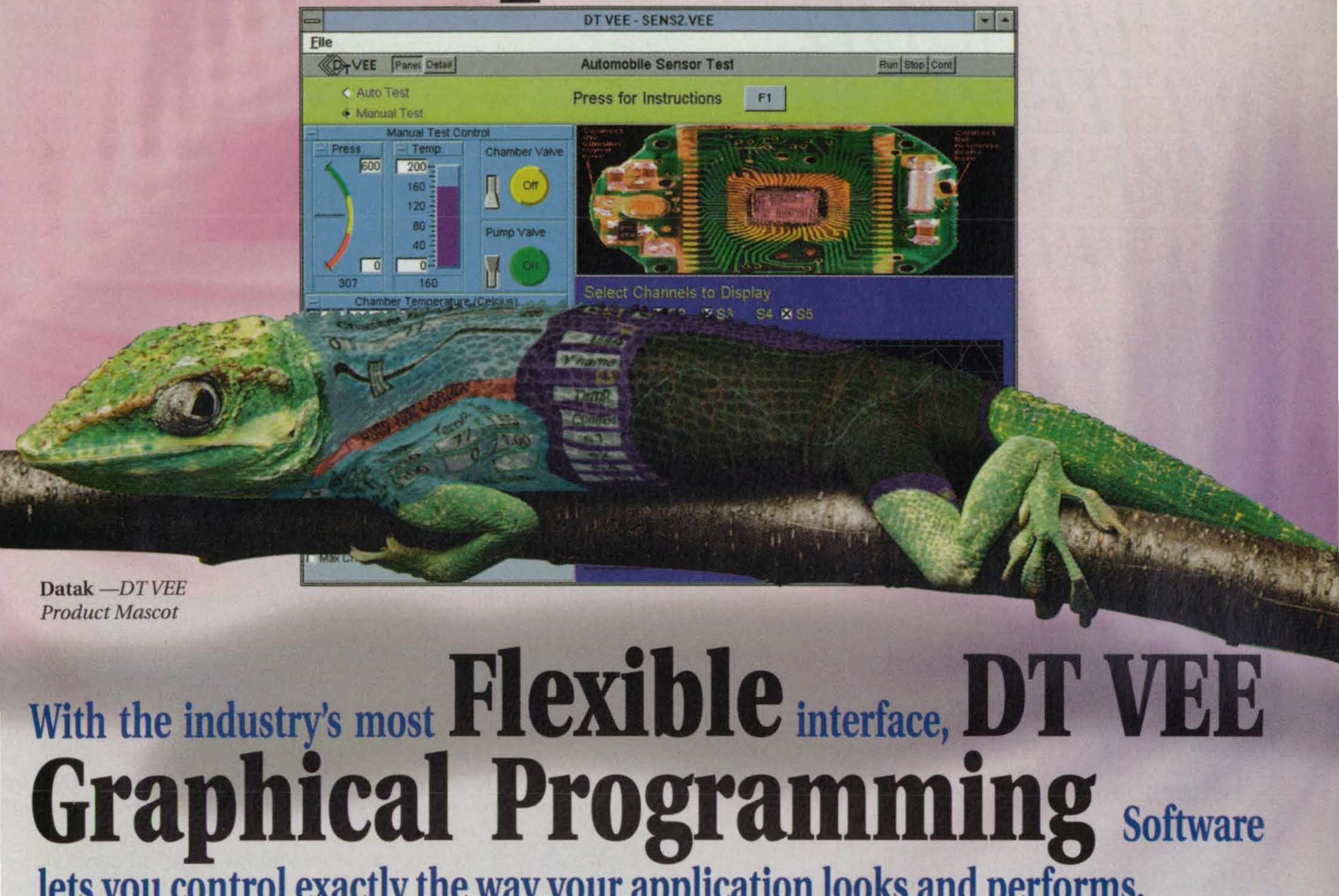

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Notebook

THE POWER TO INSPIRE

"I believed in the importance of U.S. efforts in space long before I began work on the film *Apollo 13*. The efforts of the men and women who have dedicated so much of their lives to the space program have produced tangible results that have positively impacted our lives, and the lives of all humankind. Along with these benefits, this desire has produced something unique to our collective psyche—inspiration. It is the best part of us all—the understanding that given time and money, we can figure out just about anything. The American work ethic is most perfectly displayed in the plans and accomplishments of NASA and its contributing industries. It is inspiring to see that we can, and do, put men and women into the lifeless vacuum and glorious free-fall of outer space."

(Excerpted from a letter presented by actor Tom Hanks to the U.S. Congress.)

As the long ticket lines for *Apollo 13* attest, NASA and the space program continue to capture the imagination of the American public—especially the young. The majority of the audience at a screening I attended were not even born when the actual Apollo 13 mission took place. They are the scientists, engineers, and entrepreneurs of tomorrow on whom we will count for future innovations that will keep the nation's economic engine well-tuned and running at full speed.

And they are the reason we at Associated Business Publications have teamed with NASA and the International Technology Education Association to create a new tool for educators called *NASA Technology Today*, a sample of which is enclosed with this issue of *NASA Tech Briefs*. It is designed to help teachers empower students to understand and apply science and technology and, hopefully, to inspire them to pursue careers in engineering and science. This inaugural edition focuses on some of NASA's most important and far-reaching programs—the Hubble Space Telescope, the International Space Station, Mission to Planet Earth—and on teaching resources such as the Spacelink on-line information system.

Please share this publication with your children, your colleagues' children, and their teachers. Future issues of *NASA Tech Briefs* will describe how educators can continue to receive *NASA Technology Today* for use in their classrooms.

INTERNET ACCESS

We also are proud to introduce this month a *NASA Tech Briefs* home page on the Internet. An evolving tool, it features information on NASA resources, patents, and more. The URL is: http://www.keds.com/ntb. And for details on the Technology 2005 conference, type: http://www.keds.com/tech2005.

Joseph Pramberger

Joseph Pramberger
Publisher

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Mission Accomplished

From receiving the customer order and gathering materials, to sequencing assembly steps and sending out the finished product, manufacturers share a complex task with NASA's space shuttle orbiter processing facility: process scheduling. In the late 1980s, NASA's Ames Research Center developed intelligent software called the ground processing scheduling system (GPSS) that both handles the enormity of orbiter maintenance schedules and absorbs the rapid changes so efficiently that human labor is saved along with costs. Now Red Pepper Software in San Mateo, CA, is marketing a commercial version of GPSS.

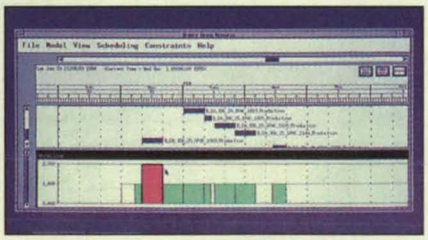
Between flights, the space shuttle orbiters are refitted and reconfigured for specific missions, and systems that showed abnormalities are overhauled. With all four orbiters passing through Kennedy Space Center's Orbiter Processing Facility (OPF), rapid-fire, clockwork scheduling is a must. Choreographing all the necessary systems and disciplines and establishing the flow management to optimize the use of labor and equipment demand integration of several disciplines including engineering, material handling, safety, and quality inspection.

Monte Zweben, then deputy chief of the Artificial Intelligence Research Branch at NASA Ames, derived an entirely new algorithm for scheduling software, which was exception-, or constraint-based. Originally written in the LISP (List Processing) artificial intelligence language, GPSS begins with a complete though possibly flawed schedule, then modifies it through many iterations until it is optimal for the team's needs–useful when there is frequent rescheduling, as in orbiter processing and many industrial applications.

The similarity to industrial settings induced Red Pepper Software, founded by Zweben after leaving Ames, to begin marketing the technology to manufacturers. An agreement with NASA grants the company two-year exclusive rights to distribute a commercial version of the system with modules for scheduling, planning, data collection, data bridges, and distribution. In return, Red Pepper is improving the system and building in a training component for the agency.

The algorithm in the improved GPSS searches through available schedule options and makes scheduling choices based upon cost factors or other weights–such as vehicle configuration or resource availability–assigned to the option. For example, for a given activity in orbiter processing, the team may consider that having the landing gear up is more important than having the payload-bay doors open, and the system would take this into account when determining the schedule.

Red Pepper rewrote the original LISP code using C++ on UNIX to make it more widely applicable and added a common relational database and graphical user interface. The changes also were aimed at manufacturers that demand open systems and standards. The company calls its new software series ResponseAgents. "The ResponseAgent is a new kind of software that goes into transactional systems, grabs all the information and brings it into memory, assembles the plan and schedule for an enterprise and presents it–but also shows what's wrong with the plan and schedule," explained Zweben.



The ResponseAgent histogram highlights a capacity violation on a production line, while the chart presents required tasks for the production schedule. (Photo courtesy of Red Pepper Software.)

Tailoring software for the specific needs of manufacturing required significant rethinking. Said Zweben: "At Kennedy we dealt with finite capacity resource–i.e., there's only so many technicians and engineers to get your job done. We also had the state constraints about the hazards and configuration of the vehicle. In the manufacturing world we have to deal not only with finite capacity but with something far more complicated–materials management. In order to make finished goods, the company has to make some sub-assembly, and that back-chains all the way to raw material. The major extension that Red Pepper is making over the original technology is the ability to handle both materials management and capacity."

The ResponseAgent shows a manufacturer's possible exceptions for its schedule, such as material shortages, capacity overloads, or orders that are scheduled to ship late. The user can resolve the exception or ask the ResponseAgent to do so. The company offers or is developing three kinds of agents: a Production ResponseAgent for automating a factory; Distribution, for automating finished-goods distribution through a logistics or distribution network; and Enterprise, which links the multiple facilities in distribution and production to give an enterprise a more global perspective on its operation.

Red Pepper already has signed contracts for the Production Response Agent. The flexibility offered by the software attracted Cisco Systems of Santa Clara, CA, a network systems supplier. Cisco's assemble-to-order manufacturing environment faces a high amount of unpredictability: supplier shortages, expedited customer orders, capacity constraints, and the level of configurability that Cisco offers its customers all add variables to a complex equation. Red Pepper's software provided the quick responsiveness that Cisco required, helping the manufacturer resolve its steady flow of exceptions and decide what to build today and a few weeks down the line.

Sun Microsystems in Mountain View, CA, also found the exception-based software amenable to its particular problems. "A global manufacturing environment such as Sun's is composed of millions of data elements that need to be considered," said Robert Worrall, Sun's director of network systems. This data includes vendor delivery, customer orders, and the final build of the product. "ResponseAgents allow you to state the relative importance of all those business drivers, and then the system can warn when your existing inventory, capacity or supplier capabilities cannot meet your customer's demands."

Back at NASA, Eric Clanton, manager of the processing crew for the orbiter *Endeavour*, has been able to cut daily staff meetings (involving about 100 people) from 45-60 minutes to less than 15 by using GPSS. "That many hours saved every week has a measurable impact on things such as overtime," Clanton said. "It's even improved my time off from work–now there is more of it."

For more information, contact David Obershaw, Red Pepper Software, 1810 Gateway Drive, Suite 150, San Mateo, CA 94404; tel: 415-525-3315; fax: 415-341-8064.

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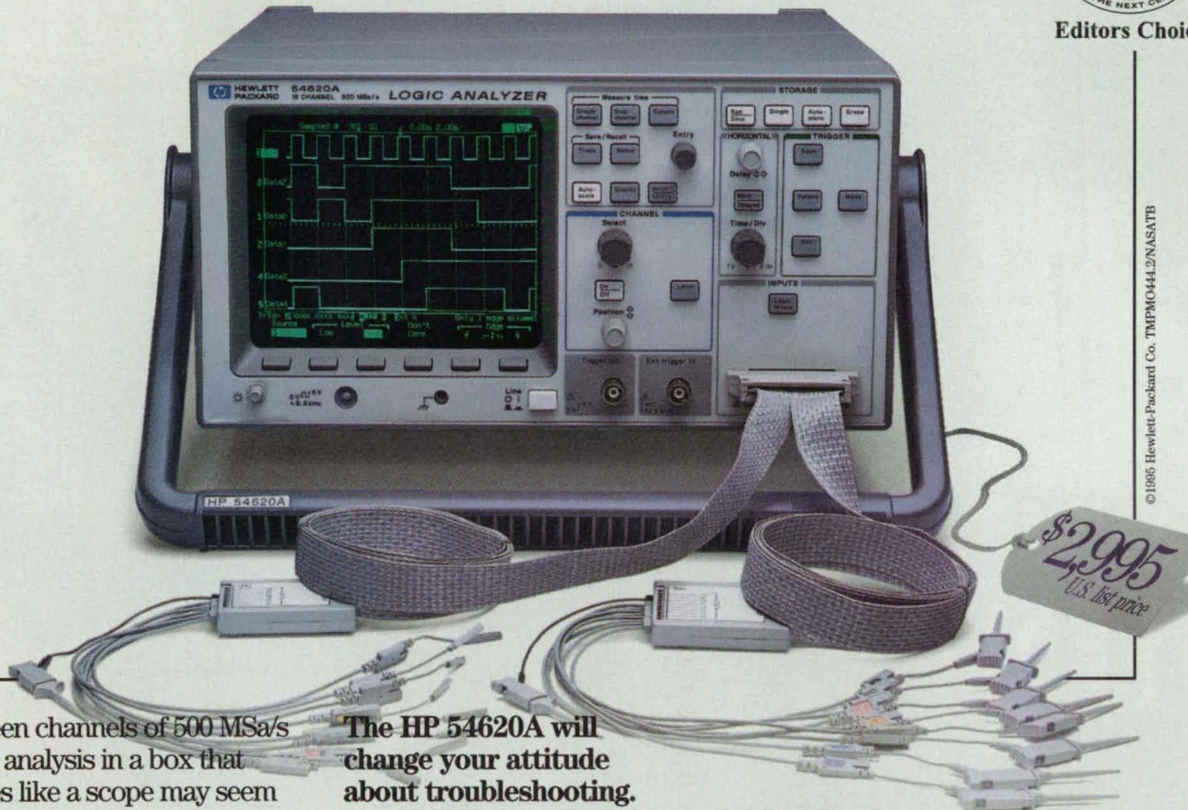

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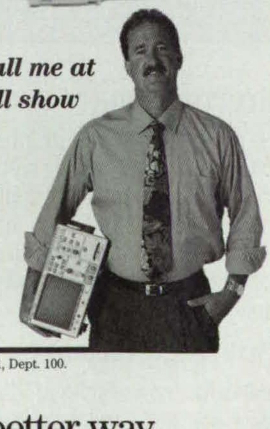

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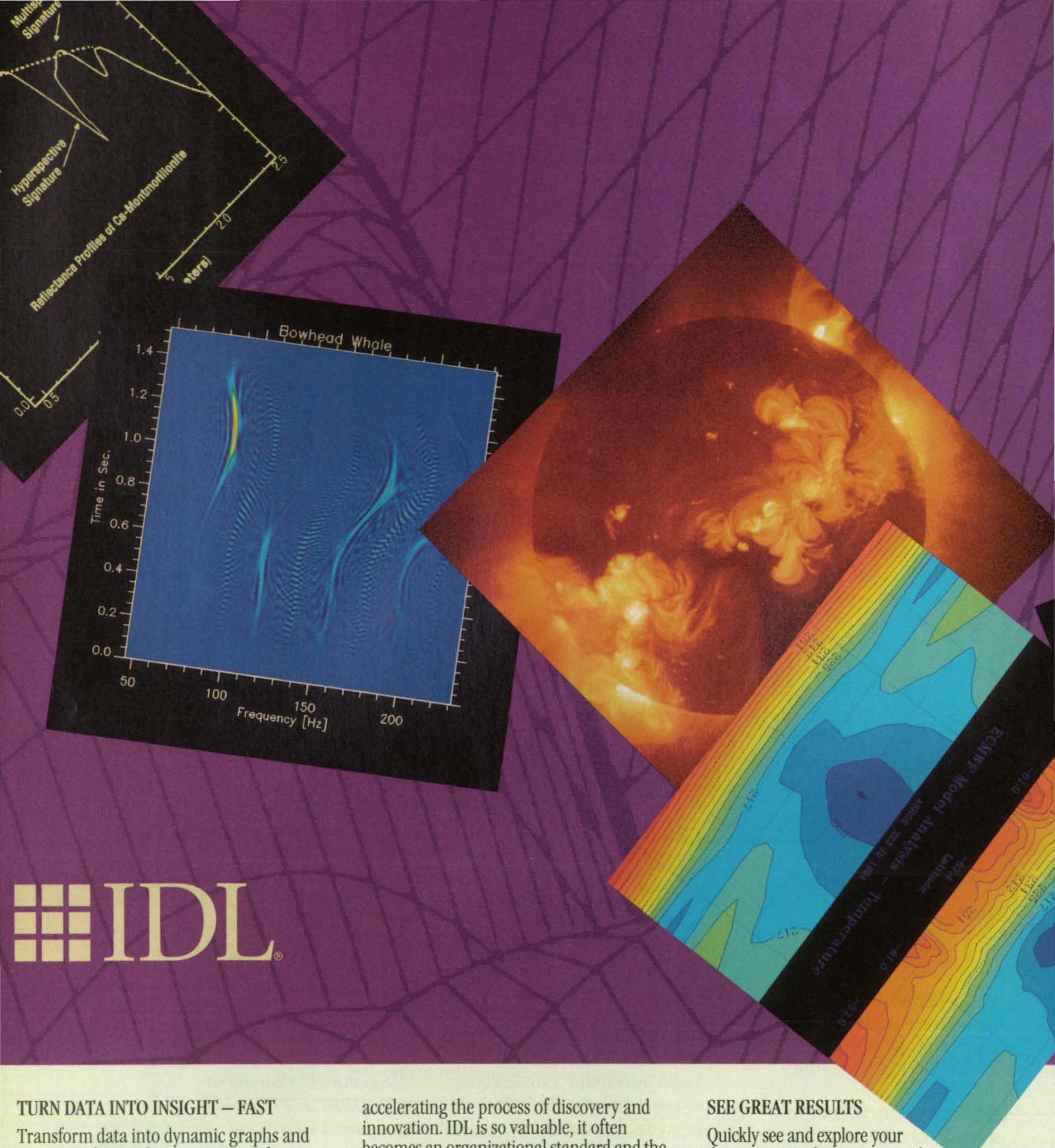

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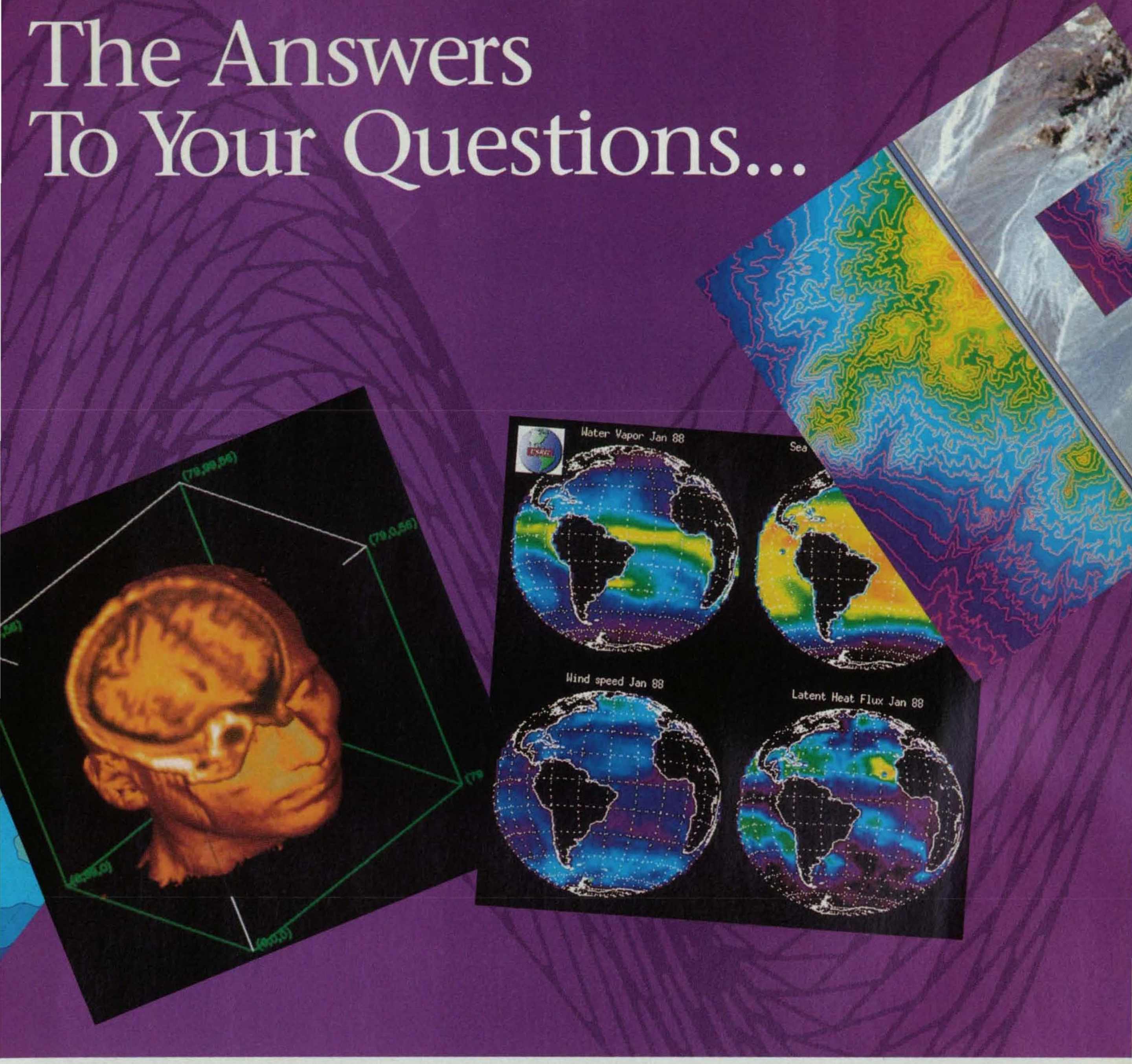
The Answers To Your Questions...



program from scratch. A few IDL functions can do the job of hundreds of lines of C or Fortran, without sacrificing flexibility or performance. Plus, IDL can call C or Fortran functions or share data with external processes to leverage other software investments. Developers using C, C++, or Fortran can also call IDL as a data analysis and visualization library, and avoid the time required to create and maintain homegrown routines.

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For More Information Write In No. 684

Goddard Space Flight Center

Goddard Space Flight Center in Greenbelt, MD, boasts the largest number of scientists of any NASA field center, exemplifying its emphasis on basic research, primarily in connection with its extensive array of data-gathering satellites. To build and maintain this satellite program, Goddard's engineering staff makes advancements in spacecraft and ground data systems, instruments, lasers, software, cryogenic sensors, and spacecraft thermal systems, among other specialties.

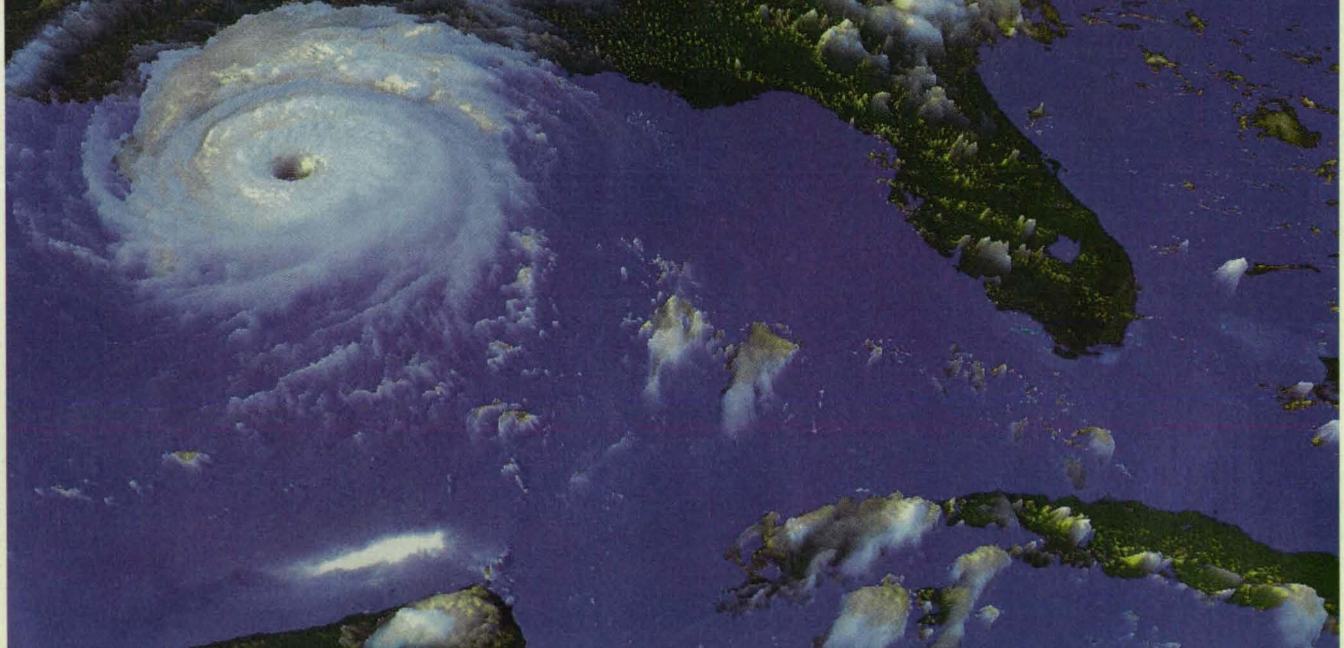
Goddard focuses on expanding the knowledge base of Earth and its environment, the solar system, and the rest of the universe through application flight projects using the shuttle, expendable vehicles, and balloons. The center was founded in 1959 by action of the NASA Administrator, and by 1960 had participated in significant space "firsts"–the first true meteorological satellite, TIRO, and the first passive communications satellite, Echo-1. Goddard was also responsible for the first satellite to intercept a comet, in 1985.

Building on its experience in Earth observation projects such as the Landsat satellites and Nimbus 7's Total Ozone Mapping Spectrometer, Goddard now manages the Earth Observing System (EOS), the centerpiece of NASA's Mission to Planet Earth (MTPE) program. A long-term research effort to study the planet as a global environmental system, MTPE aims to increase the understanding of environmental functions to better inform policy-making. The EOS consists of a set of satellites monitoring and studying various characteristics of terrestrial and atmospheric composition and function. The EOS Data and Information System at Goddard will gather and process EOS data for use by researchers worldwide.

Goddard also is home to the Hubble Space Telescope's (HST) Operations Control Center, which issues all commands to the telescope and receives all data gathered by the observatory before sending it to researchers around the world. It also served as the control site for the HST First Servicing Mission in December 1993, when the observatory's flawed optics were corrected during a space shuttle mission.

Through its Technology Transfer Office (TTO), Goddard markets its expertise, facilities, and technology to private companies, other government agencies, and academia. It forms partnerships, enters into funded or unfunded Space Act agreements and cost-shared contracts, and licenses patented inventions.

A significant facet of Goddard's partnering is facilities utilization, whereby many of the center's facilities are made available–on a noninterference basis–for research and development, analysis, and product performance testing. The Engineering Services Division maintains the center's design and fabrication capa-



Scientists in Goddard's Laboratory for Atmospheres have been using the scalable parallel MasPar MP-2 and Silicon Graphics workstations to compute digital elevation maps and renderings of weather phenomena, such as that of Hurricane Andrew, from raw data collected by multiple satellites.

bility through three branches: Machining Technology, Fabrication Engineering, and Environmental Test Engineering and Integration. Machining Technology provides complete manufacturing facilities for Goddard, including machining equipment such as lathes and milling machines that can handle exotic aerospace materials and composites. For computer-aided manufacturing, the precise, numerically controlled machining center can turn out large parts through automation.

Fabrication Engineering constantly evaluates and develops processes for plating, welding, and fabricating sheet metal structures, plastics, and composites structures, with an orientation toward spacecraft assembly. Facilities include a spacecraft assembly area and assembly cleanroom, inert gas welding chamber, seam welder, vacuum furnace, composites manufacturing laboratory, and autoclave for curing fiber-reinforced epoxy composites.

Environmental Test Engineering and Integration primarily tests spacecraft, instruments, and components in various environments they might experience from ground handling to flight. Equipment in this branch includes a vibration control system, acoustic test chamber, high capacity centrifuge (up to 2268 kg at 30 g), universal static test facility, modal survey test facility, large EMC facility, magnetic field component test facility, various-sized thermal vacuum chambers for component and complete spacecraft testing, and solar simulators. Goddard also has several Class 10,000 cleanrooms and cleanroom tents, a large Class 1000 high bay cleanroom, and a new Class 10 cleanroom for semiconductor fabrication.

Goddard's Software and Automation Branch provides tools and computer technology to the center's other directorates and presents its available software and services in a catalog. Many of these packages have applications beyond the center's borders. The Request-Oriented Scheduling Engine (ROSE), available through COSMIC, is a general-purpose scheduling tool featuring scheduling plans, goals, and request language. The Dynamic Systems Dynamic Simulator Plus, a systems development tool already used by projects inside and outside Goddard, such as the Space Station, models a system's traffic to determine sizes of data links and buffers, and component speeds, helping to prevent bottlenecks and other performance problems that can be costly to fix in development or deployment stages. The award-winning Transportable Applications Environment Plus provides tools for developing and managing graphically oriented user interfaces and common application-executive services.

Spinoffs and Payoffs

Goddard's partnerships have yielded many practical payoffs. With Life Systems Inc. in Beachwood, OH, Goddard has assisted the Department of Veteran's Affairs in developing an implantable, miniature Functional Electrical Stimulation system for restoring mobility lost in spinal-cord-injury patients. Scientific and Commercial Systems Corporation, Beltsville, MD, and Goddard devised an Earth Alert Program–weather satellite technology to transmit severe weather or natural disaster information to remote areas. In 1994, this system was adapted for Hawaii and the Republic of Fiji.

Management Technology Inc. (ManTech) has licensed technology from Goddard for one purpose and expanded it into other markets. Goddard designed a flexible robot that navigates over virtually any surface, with cables controlling the robot's actuators so it can bend and adjust itself to irregularities. ManTech incorporated the technology into its Advanced Transmission Line Inspection System, which maneuvers over high-voltage transmission lines to inspect them, curtailing human exposure to the hazards. High-voltage transmission line inspection is a $300-500 million market. Now ManTech is extending the technology into a Tower Painting Robot, tapping into the $500-700 million tower painting and sandblasting market.

Other technology transfers from Goddard include the PIMS automatic insulin dispensing device, which is surgically implanted so that patients do not have to inject themselves daily. Computer Systems Applications Inc. of Chattanooga, TN licensed Goddard's "capaciflector" sensor technology–which increases detection range and sensitivity in a more compact, rugged package than other sensors–for use in engineering, agriculture, and the automotive industry. The Houston Advanced Research Center has partnered with Goddard on the Light Detection and Ranging (LIDAR) Airborne Topographical Mapping System, which uses measurements from laser reflections bounced off terrain and back to the aircraft to map terrain, inventory forests, map water depth, and detect pollution on water.

Goddard's Landsat-4 and -5 satellites gathered the data in this false-color composite image from southern Rhodonia, Brazil. As labeled, different colors represent tropical forest, deforestation, and regrowth. The map also identifies areas of isolated forest.

Among the many technologies the TTO is promoting are a laser paint that emits high radiance when shot with a laser; a high density, high performance capaciflector array for precision sensing; gamma radiation analysis for elemental detection; and capillary pumped loops for thermal control in outerwear and outdoor gear.

For further information, contact George Alcorn, chief, or Nona Minnifield, commercial research manager, Office of Commercial Programs, Building 11, Room C1, Mail Stop 702, Greenbelt, MD 20771; Tel: 301-286-5810; Fax: 301-286-1717.

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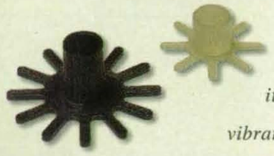

Engineers chose Zytel® HTN for ITT Automotive's windshield wiper motor spiders for its resistance to heat aging and distortion, moisture, cold shock and vibration stress. Crastin® PBT was the first engineering polymer to replace metal for the windshield wiper arm. It made assembly easier by reducing the number of parts required from 12 to 5.

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TECHNOLOGY 2005

EXHIBITS PREVIEW

More than 60,000 square feet of exhibits by government laboratories and agencies, universities, and industry will be on display at Technology 2005 at the McCormick Place Convention Center in Chicago from October 24-26, 1995. Attendees will view new inventions, products, and technologies available for license, joint development, or sale in areas such as electronics, computers/software, materials, sensors, data acquisition, mechanical components, and manufacturing. Following are this year's exhibitors (as of July 28).

Aeromobile Inc. 730
Rock Island, IL

Aeromobile will highlight air cushion vehicles in tubes that offer inexpensive, fast, frictionless, elevated, automatic, horizontal elevators as "people movers" for any span over land, water, roads, or rails.

Aerospatiale 211
Les Mureaux Center, France,

will describe its role in various European space projects and exhibit new products and technologies in areas such as thermal protection, magnetic bearings, and HP filament winding.

American Heuristics Corp. 831
Triadelphia, WV,

is an advanced software technology consulting and training company specializing in applying AI and OOPS to complex problems in business, industry, and government.

American Institute for Research and Development 442
Westfield, MA

The Institute will display new inventions that will be available for licensing to manufacturers.

Ames Laboratory 529
Ames, IA,

will present advanced materials and coatings technologies, powder metallurgy, quantitative NDE instrumentation/techniques, environmental characterization systems, new analytical methods, and materials information services/resources.

Applied Research Laboratory 705
Pennsylvania State University
State College, PA,

will present Undersea Warfare Technologies, including acoustics, controls, signal processing, propulsion, materials, and manufacturing.

Argonne National Laboratory 708
Argonne, IL,

conducts research focused in five primary areas: transportation technology, engineered materials, energy/environmental technology, advanced manufacturing, and computing (advanced computing and modeling/simulation).

Aviation Week Group/ McGraw Hill 713
New York, NY,

is a global print and electronic information network designed to serve aviation/aerospace buyers. Publications include *Aviation Week & Space Technology*, World Aviation Directory, *Business & Commercial Aviation*, *A/C Flyer*, AWG Newsletters, and Show News. Electronic print includes Aviation/ Aerospace OnLine and the WAD CD-ROM.

BF Goodrich Aerospace Aircraft Integrated Systems 522
Vengennes, VT,

specializes in signal processing for assessing aircraft health, utility subsystem integration, remote interrogation sensor electronics for composite health monitoring, and light-energized sensing for fluid measurement.

BHK, Inc. 219
Pomona, CA,

will exhibit UV and IR light sources and power supplies; electro-optical and opto-mechanical assemblies; low-pressure mercury, zinc, and cadmium lamps; wavelength calibration lamps; and IR filament lamps.

Bosma Machine and Tool Corp. 537
Tipp City, OH,

is a contract machining and fabricating specialist, performing precision machining of telescope and earth station components and reflector panels for millimeter and sub-millimeter antennas to 6 microns rms.

Brookhaven National Laboratory 601
Upton, NY,

will focus on basic and applied research in the physical, biomedical, and environmental sciences and in selected energy technologies for commercialization.

Catalyst Advertising 107
Fallbrook, CA,

has 3400 patents available for license, as well as world patent databases and a PHL patent hotline BBS.

Center for Research on Parallel Computation 725
Houston, TX

CRPC will show how taking hundreds or thousands of microprocessors and making them work in parallel on a single computing task can be productively applied in industries such as energy, environmental remediation, aerospace, and medicine.

Centro Estero Camere Commercio Piemontesi 500
Torino, Italy

The Technology Transfer Center's main goal is to promote and develop international business relations and high technology transfers.

CorpTech 116
Woburn, MA

CorpTech provides detailed information on 42,000 US technology manufacturers. Technology sources, or potential sources of funding for technologies, are available.

Cybernet Systems 410
Ann Arbor, MI,

will exhibit the PER-Force hand controller used for telerobotics, virtual reality, and simulation. The device produces force-reflection along six degrees of freedom to "virtual" force feedback.

DOE Nevada Laboratories 605
Las Vegas, NV

"America's Best-Kept Secret" is a set of laboratory facilities seeking potential partners for development, evaluation, and deployment of advanced sensor systems in remote environments.

Ecosmarte of North America 700
Bloomington, MN,

will offer literature describing electronic oxidation and ionization with brine-free point-of-entry technology and 100% chlorine-free pool and spa technology.

Edison Welding Institute (EWI) 614
Columbus, OH

EWI provides materials joining manufacturing technology development and outreach via the National Excellence in Materials Joining (NEMJ) and Navy Joining Center (NJC) programs.

Electronic Displays Inc. 637
Wood Dale, IL,

manufactures large LED readouts for indoor and outdoor use, counters, timers, and message signs with 1" to 12" characters.

Environmental Protection Agency 807
Washington, DC

EPA's FTTA exhibit will contain information on the FTTA program, CRADAs, and how to get involved, as well as information on licensing agreements and technology transfer.

Federal Aviation Administration Technology Transfer Office 207
Atlantic City, NJ,

will offer information on technologies presently under development and/or deployment, including GPS, aircraft safety, ATC, airport capacity and runways, human factors, surveillance, and radar technology.

Federal Highway Administration 524
Washington, DC

The FHA will display the latest innovations in areas such as highway safety technologies and products developed by SHRP.

Federal Laboratory Consortium 620
Sequim, WA

The FLC's purpose is to promote and strengthen technology transfer nationwide by coordinating technology transfer needs of the more than 600 member R&D laboratories, centers of their potential collaborators, and their parent agencies.

FLIR Systems Inc. 604
Portland, OR,

will present a range of high-resolution handheld and laboratory infrared imaging systems with applications in R&D, non-destructive evaluation, and quality assurance.

Force Imaging Technologies 518
Chicago, IL,

will exhibit thin (0.003"), flexible force sensors and systems that provide static and dynamic contact pressures over a wide load range from less than 1 psi to over 20,000 psi.

Gulf Coast Alliance for Technology Transfer 731
Fort Walton Beach, FL

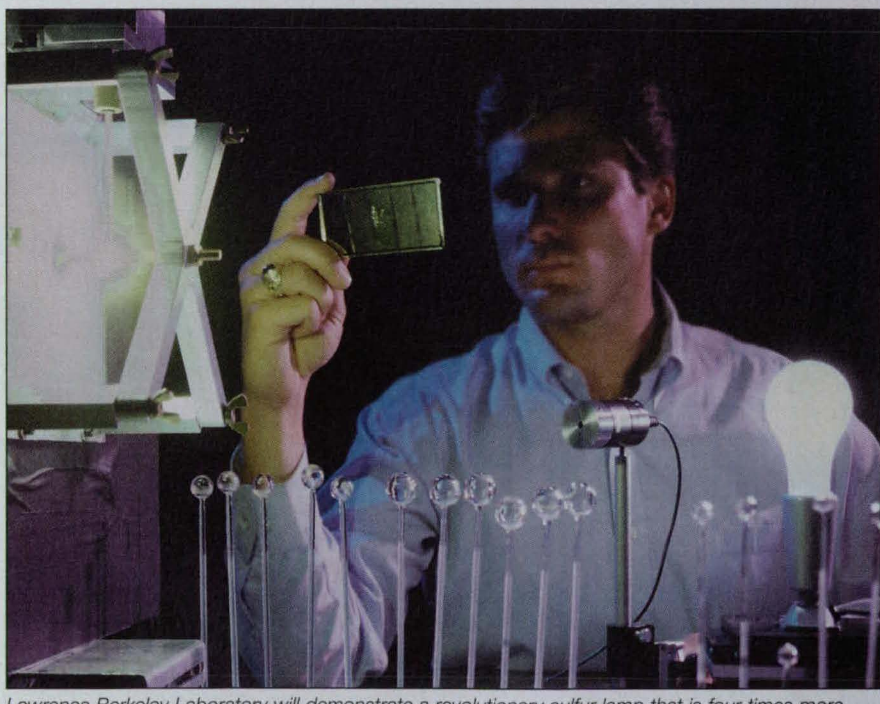
GCATT's federal laboratories and universities offer unique technology and test facilities representing numerous categories, including environmental, electronics, optics, magnetics, sensors, materials, and human performance.

Idaho National Engineering Laboratory 424
Idaho Falls, ID,

will display a new concept in high-speed mass transit, the CyberTran system, under development at the laboratory. The system represents affordable, high-speed, energy saving mass transit that is an electrically-powered, steel wheel-on-steel-rail.

Imi-Tech Corp. 619
Elk Grove Village, IL,

will display Solimide® polyimide foam products that are fire-resistant, lightweight, have little outgassing, are flexible and resilient over a wide temperature range, and have good thermal and acoustic insulation properties.



Lawrence Berkeley Laboratory will demonstrate a revolutionary sulfur lamp that is four times more energy-efficient and 700 times brighter than a conventional incandescent bulb.

Ingenieurschule Biel — 504
Biel, Switzerland,

will present Microspace PC for embedded industrial controlling, CAN-Field bus controlled I/O modules, and technical applications of nanotechnology.

Innovative Insulation Inc. — 515
Arlington, TX

Super R radiant barriers reduce heating and cooling costs by reflecting radiating heat. They may be used independently or to increase the performance of conventional insulations.

Integrated Sensors Inc. — 623
Utica, NY,

will demonstrate its first commercial spin-off product from the NASA Relative Attitude and Position Estimation Program (Phase II). The system tracks an object in real time and provides measurements of the object's position and angular orientation.

Inter Research Inc. — 446
Edgewood, IL,

will offer training packages to enhance neural capabilities and document the results. Researchers and management who constantly work at peak levels immediately can benefit.

Kaiser Hill Co. — 837
(Rocky Flats Environmental Tech Site)
Golden, CO

Kinesix — 443
Houston, TX

Kinesix will highlight Sammi™, a dynamic data visualization tool for development, testing, and maintenance of graphical applications such as real-time command and control systems, and mission-critical client/server applications.

Kollmorgen Inland Motor — 827
Radford, VA

Kollmorgen designs and manufactures custom motion control components and systems for the aerospace and defense industries.

Lawrence Berkeley Laboratory — 704
Berkeley, CA,

is seeking partners to commercialize its technologies. LBL has expertise in energy, environmental, materials, chemistry, computing, and biotechnology areas.

Los Alamos National Laboratory — 418
Los Alamos, CA

Information on environmental, materials, manufacturing, computing, and biological technologies will be on display.

Machida Inc. — 839
Orangeburg, NY,

will highlight fiber-optic borescopes and related accessories with diameters as small as 0.5 mm and working lengths to 20 feet. Other products include custom instruments and a standard line of borescopes, video equipment, and light sources.

Meridian Laboratory — 606
Middleton, WI

A next-generation infrared imaging camera to be exhibited by FLIR Systems uses focal plane array (FPA) technology to create a high-resolution image.

Micro Surface Corp. 314

Morris, IL,

is an engineering coatings company specializing in developing solutions to wear, lubricity, and release applications. Technology transferred from NASA and other aerospace development is utilized to solve industrial problems.

Nanophase Technologies Corp. 436

Burr Ridge, IL,

manufactures nanocrystalline ceramic and metal particulates. Powders are available in a range of sizes from 5 to 100 nm (0.005 micron to 0.1 micron).

NASA 123

Washington, DC

NASA will present the technological advances listed below from these NASA field centers: Ames Research Center (Moffett Field, CA), Dryden Flight Research Center (Edwards, CA), Goddard Space Flight Center (Greenbelt, MD), Jet Propulsion Laboratory (Pasadena, CA), Johnson Space Center (Houston, TX), Kennedy Space Center (Kennedy Space Center, FL), Langley Research Center (Hampton, VA), Lewis Research Center (Cleveland, OH), Marshall Space Flight Center (Huntsville, AL), and Stennis Space Center (Stennis Space Center, MS). Key technologies resulting from the nation's space program also will be described, as well as spinoffs from aeronautics and space research.

Energy: New fuel cells; ultrasonic leak detectors

Environmental Quality: Low-temperature oxidation catalyst; new soil medium; system for converting organic toxic chemicals to safe chemicals

Human Systems: Acoustically-based fetal heart rate monitor; dried blood chemistry method; DeBakey Ventricular Assist device (VAD); thermal transfer technology; CCD-based Mosaic digital mammography

Information and Communication: GIPSY/GPS infrared positioning system; GPS receiver technology; text retrieval system; robotic/telecommunication/information technology; intelligent computer-aided training; fuzzy logic/neural network systems

Manufacturing: Technologies in rapid prototyping; vacuum plasma spray; diagnostic/online sensing devices; robotics; advanced joining; smart tools

Materials: Advanced polymer coatings; VOC thermally sprayed coatings; ceramic near-net shape manufacturing; welding materials

Transportation: Technologies to enhance vehicle performance, reduce cost, and improve quality

Miscellaneous: Real-time non-volatile residue (NVR) monitor; neural network for processing (software); simulation virtual machine; microwave heart catheter; Mission to Planet Earth

NASA Tech Briefs 615

New York, NY

NASA Tech Briefs magazine has first publishing rights to new inventions and innovations by NASA and its contractors in electronics, materials science, computer software, mechanics, and other high-tech fields.

National Renewable Energy Laboratory 406

Golden, CO,

will present an introduction to the laboratory and its research resources, including information on R&D and partnership opportunities in industrial and utility energy technologies, buildings energy management, alternative fuels, wind systems, photovoltaics, and basic energy sciences.

(continued on page 32)

Figure: CD-ROM disk magnified 13,000 times, showing individual "data pits" struck by the laser beam (red circle).
Product Spec: Quadruple speed operation, resistant to shocks in portable use.
Requirement: Track following within 1×10^{-7}meters. (Like driving a car at four times the speed of sound during a hurricane and staying on course within half a millimeter.)

(Photograph courtesy of Philips Electronics N.V., Netherlands.)

SIMULINK is a powerful, interactive environment for system modeling, analysis, and simulation, which is what Philips Electronics needed while developing new servo track-following techniques. Indeed, over 10,000 engineers worldwide have proven SIMULINK to be effective as well in the design of powertrains, aircraft, satellites, and industrial processes.

Create models graphically

With SIMULINK's intuitive GUI, systems can be modeled quickly and easily. Just drag and drop icons into block diagrams—without writing a single line of code.

Extensive block libraries

SIMULINK includes over 200 built-in blocks to simplify model building. System behavior can be accurately simulated by combining a wide variety of block types. These include linear, nonlinear, and logic elements used to define continuous-time, discrete-time or hybrid systems.

Open architecture

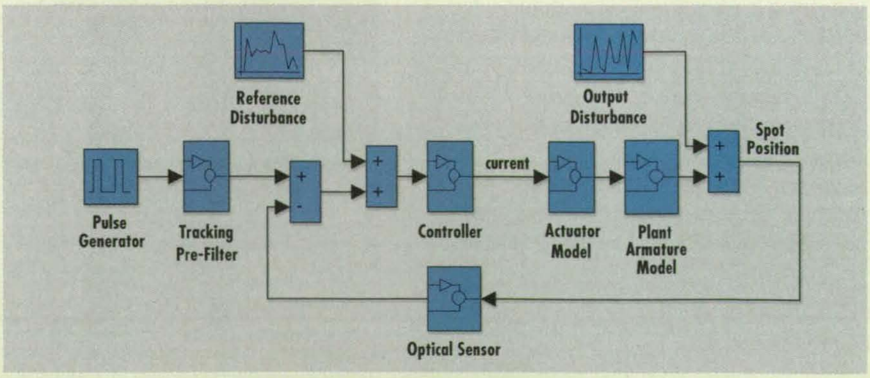
SIMULINK's open architecture allows easy creation of custom blocks, modification of existing blocks, and assembly of reusable custom block libraries for sharing among entire departments or with outside contractors.

Real-time testing

Real-Time Workshop™ offers an open system approach to rapid prototyping—one of the most important recent innovations in system design.

Real-Time Workshop generates highly portable C code directly from block diagrams. This C code is optimized for execution speed. It runs on dSPACE boards, under VxWorks

In SIMULINK, the entire system, including plant, controller, actuators, and sensors, can be simulated to explore and optimize performance.



The fast track from idea to implementation.

SIMULINK®

Result: "Design and Implementation of a QFT Controller for a Compact Disc Player," *Journal of Systems Engineering*, Vol. 4, 1994.
MathWorks Products Used: SIMULINK, MATLAB, QFT Toolbox, and other toolboxes.

on VME systems, on PCs, or on your own hardware, for dramatic reduction of design cycles and delivery of products on schedule.

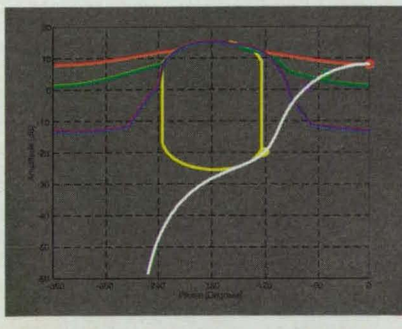
New blocksets for special applications

New SIMULINK blocksets provide an extensive library of components for specialized applications.

The Fixed-Point Blockset enables engineers to build cost-effective compensators and other control structures. Users can analyze word length, binary-point scaling, rounding, and quantization effects in order to bring their designs another step closer to production.

The DSP Blockset adds special components for buffering, FFTs, and spectral computations, as well as operations on complex signals. A wide range of DSP techniques is built in, and custom algorithms can be added without the need for low-level programming.

Engineers can design robust, low-order controllers for SIMULINK models using the QFT Toolbox.



SIMULINK Product Family

- *Real-Time Workshop*
- *Fixed-Point Blockset* **NEW**
- *DSP Blockset* **NEW**
- *Nonlinear Control Design Toolbox*
- *SIMULINK Accelerator*

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We'll also send along our comprehensive Rapid Prototyping Guide or the *Journal of Systems Engineering* technical paper on servo track following. Your choice.

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(continued from page 29)

National Security Agency 525

Ft. Meade, MD,

will highlight microelectronics, computing, communications and networking, signal processing and advanced mathematics technologies.

National Space Society 612

Washington, DC

NSS is a non-profit membership organization supporting space exploration and development through public education, political activism, local chapters, and publication of *Ad Astra* magazine.

National Technology Transfer Center 609

Wheeling, WV

NTTC was created to assist the private sector in assessing the technology, knowledge, and expertise located within the federal laboratories. The center's services are free and can be utilized by calling a toll-free number.

Naval Research Laboratory 600

Washington, DC,

will exhibit R&D programs available for licensing in the areas of advanced materials, biomolecular engineering, chemical processing, electronics, optics, sensors, and information technology.

Novespace 215

Paris, France,

will describe European technology transfer networks established around Novespace and will feature various technology catalogs.

Oak Ridge Centers for Manufacturing Technology 400

Oak Ridge, TN

The ORCMT is a national industrial resource for applied research, demonstration, fabrication, development, prototyping, and education.

Olympus America - Industrial Fiberoptic Div. 514

Lake Success, NY,

will highlight remote visual inspection equipment, including borescopes, fiberscopes, and video imagescopes.

Optics Technology Inc. 616

Pittsford, NY

A designer and manufacturer of unique optical and mechanical components and assemblies, the company will highlight close-tolerance miniature and subminiature systems.

Orbital Sciences Corp. 608

Dulles, VA,

is a space technology company that designs and manufactures a range of space-related products and services, including launch vehicles, spacecraft systems, and communications and information systems.

Palintest 629

Erlanger, KY,

manufactures high-quality portable water testing instrumentation, including the SA1000 scanning analyzer for measuring lead within three minutes in the range from 2 to 100 µg/L.

Phillips Business Information Inc. 706

Potomac, MD,

will present newsletters that arm readers with business and marketing intelligence for use in the high-tech niches of today and tomorrow.

Powertronic Systems Inc. 316

New Orleans, LA

PSI has been a military/commercial electronics design and manufacturing contractor, as well as a reliability and maintainability software vendor for over 15 years.

Princeton University Plasma Physics Laboratory 603

Princeton, NJ

PUPPL will highlight fusion energy research and plasma science technologies relative to commercialization.

Proto Manufacturing 511

Oldcastle, Ontario,

will display the latest advancements in automated, nondestructive test systems.

Society for the Advancement of Material and Process Engineering (SAMPE) 700

Covina, CA,

will offer literature on the 41st International SAMPE/Symposium at the Anaheim Convention Center in Anaheim, CA, from March 25-28, 1996. The symposium will feature 200 papers and 300 exhibits on advanced materials and manufacturing processes.

Sophia Systems and Technology 701

San Jose, CA,

will demonstrate the CircuitWriter System, an environmentally friendly, in-laboratory machine for same-day fabrication of multilayer circuit boards. It accepts industry-standard Gerber and NC drill files, and the boards pass IPC Class 2 standards.

Superior Products/ International II Inc. 700

Kansas City, MO,

will display literature on Super Therm water-based, insulative, fire-resistant paint that withstands extreme temperatures and provides insulation equivalent to an R-19 or 6" to 8" of batt insulation.

Technology Access 414

Novato, CA,

is a concise, independent, practical newsletter of analysis and opportunities in technology transfer, commercialization, defense conversion, and policy that includes inventions for all industries, contacts, and a free information hotline.

Technology Transfer Business Magazine 627

Vienna, VA,

is "the magazine for profitable partnerships," published quarterly for strategic planners in technology businesses.

Technology Transfer Society 428

Indianapolis, IN,

is a non-profit organization committed to the professional development of individuals and firms involved in technology commercialization.

Thermo Electron Tecomet 438

Wilmington, MA,

will highlight specialized machining, mechanical subsystem assembly, fabrication, and forging operations.

Thiokol 423

Brigham City, UT,

will highlight technologies developed in internal R&D or DOD/NASA programs that show potential for commercialization, new propulsion concepts, or enhanced environmental processes.

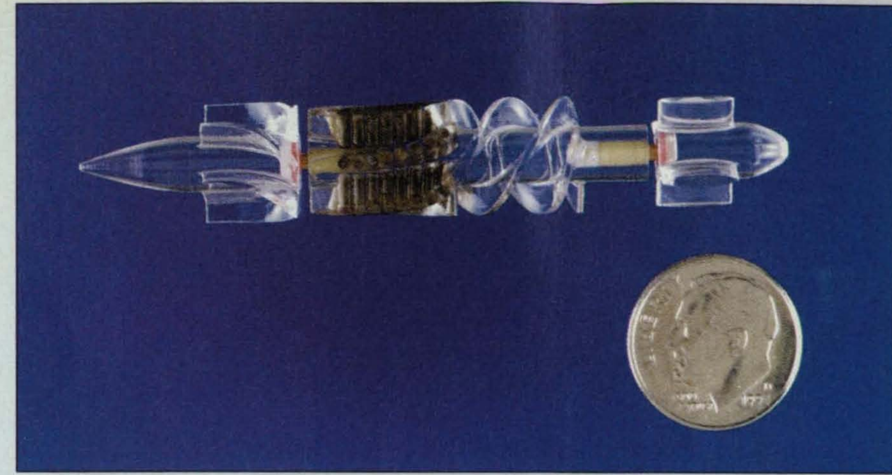
Tiodize Co. 508

Huntington Beach, CA,

will exhibit anti-corrosion coatings, solid film lubricants, Teflon coatings, self-lubricating composites, composite fastener products, degreasers, hard anodize with Teflon, mold releases, water-based coatings, and titanium anodize with no dimensional change.

University of Wisconsin - Madison 412

Madison, WI



Among the licensable technologies to be exhibited by NASA's Johnson Space Center is a small, implantable Ventricle Assist Device (VAD) that helps weak hearts pump blood. Developed with the Baylor College of Medicine, the VAD has only one moving part – an inducer/impeller that rotates between 10,000-12,000 revolutions per minute.

US Air Force Armstrong Laboratory 118

Brooks AFB, TX

The lab's activities include human-centered technology in biodynamics, biocommunications, environics, occupational and environmental health, directed energy bioeffects, human engineering, and aerospace medicine.

US Air Force Phillips Laboratory 513

Kirtland AFB, NM

US Air Force Science & Technology 306

Wright-Patterson AFB, OH,

will present the latest Air Force technologies with applications in the medical, environmental, information management, and educational fields; dual-use technologies; and the Air Force tech transfer program.

US Army Armament Research Development & Engineering Center 435

Picatinny Arsenal, NJ

The US Army ARDEC welcomes interaction with industry, academia, and other government agencies to diversify its technology base. Information about selected technologies, along with demonstrations of one of ARDEC's premier technologies, will be presented.

US Army Combat Systems Test Activity 437

Aberdeen Proving Ground, MD

Combat Systems Test Activity's world-class test instrumentation includes digital data acquisition systems and high-speed photography, such as the color Hadland camera.

US Army Department of Army Research Labs 427

Adelphi, MD,

consists of seven laboratories that provide America's soldiers with military, product-oriented, scientific research and advanced technologies. Research focuses on electronics and power sources, advanced materials and manufacturing processes, vehicle structures and propulsion, sensors, weapons technology, and human factors engineering.

US Army Tank-Automotive Research, Development & Engineering Center (TARDEC) 433

National Automotive Center

Warren, MI

The National Automotive Center is a dedicated initiative set up by the US Army TARDEC to foster technology transfer and dual-use tank-automotive R&D among government, industry, and academia.

US Department of Agriculture Agricultural Research Service 318

Office of Technology Transfer

Beltsville, MD

USDA's Agricultural Research Service, with 113 laboratories nationwide, offers opportunities for small and large corporations. Information on technology transfer programs and research projects will be exhibited.

The Savannah River Technology Center will demonstrate a software system that enables robots to navigate independently and monitor their environment—critical for hazardous work sites.

US Department of Energy Kansas City Plant (AlliedSignal) 415

Kansas City, MO,

will present a wide spectrum of mechanical, electrical/electronics, rubber, and plastic manufacturing capabilities supporting prototyping and product development for commercialization.

US Department of Energy Office of Clean Coal Technology 106

Gaithersburg, MD

The US DOE Clean Coal Technology Demonstration Program is a $7.14 billion cost-shared industry/government technology development effort, demonstrating a new generation of advanced coal-based technologies, moving the most promising into domestic and international marketplaces.

US Department of Energy Office of Technology Utilization 200

Washington, DC

The DOE's programs, laboratories, and facilities seek mutually beneficial cooperative R&D partnership and technology transfer opportunities with US companies in many scientific and technical fields.

US Department of Energy OTD (Triodyne) 624

Niles, IL

To address the needs of the DOE's Environmental Management program, the Technology Development program researches new and innovative technologies and works with other programs within the DOE, other federal agencies, national laboratories, universities, and the commercial sector to maximize research efforts and ensure safe and efficient cleanup of the nation's nuclear weapons complex.

US Department of the Interior, US Bureau of Mines 206

Washington, DC,

will display results of federally-funded mining, materials, water resources, and other research and information studies.

US Navy Best Manufacturing Practices 809

Center of Excellence

College Park, MD

The BMP Center of Excellence operates under a cooperative agreement with the Department of Commerce's National Institute of Standards & Technology and the University of Maryland. BMP identifies the best practices in US industry and promotes technology transfer and information exchange.

US Navy Research, Development, Test & Evaluation Labs 100

Arlington, VA

Eight Navy research, development, test, and evaluation activities will be featured, including laboratories from the Naval Air Warfare Center, Naval Civil Engineering Laboratory, Naval Command, Control and Ocean Surveillance Center, Naval Medical Research & Development Command, Naval Surface Warfare Center, and Naval Undersea Warfare Center.

US Navy SBIR Program 821

Arlington, VA

Supporting 31 science and technology areas, the Navy SBIR Program gives small businesses an opportunity to put their ideas to work in Navy/DOD programs.

(continued on page 40)


Mind
PERFORMANCE TIMES ON PRO/ENGINEER v.14
ALPHASTATION 600 5/266 (L2)
88 sec.
SGI R4400/200 (XZ)
154 sec.

(continued from page 36)

Van Nostrand Reinhold 805

New York, NY,

publishes solution-oriented books for professionals in all industries, focusing on emerging strategies for competitive companies in the information age. Topics include information, environmental, biomedical, manufacturing, and imaging technology, with feature titles such as: *Cheryl Currid's Guide to Business Technology, Cyberstrategies*, and *Global Advantage on the Internet*.

Vector Fields Inc. 342

Aurora, IL,

will exhibit 2D/3D electromagnetic design software and finite element-based software to optimize design of electrical equipment. Products include OPERA-3D (TOSCA/ELEKTRA/SOPRANO and SCALA), OPERA 2D, and PC-OPERA.

Westinghouse - Savannah River Company 709

Aiken, SC

Developing real solutions to real problems is the role of the Savannah River Technology Center, the Savannah River Site's applied research and development laboratory.

SBIR PAVILION

The following companies have received Small Business Innovation Research (SBIR) program grants from federal laboratories or government agencies to support the development of their technological innovations. These companies will be featured in a special area of the exhibit hall.

Advanced Modular Power Systems Inc.

Ann Arbor, MI

The company will present:

•the Alkali Metal Thermal-to-Electric Converter (AMTEC) for converting heat directly into electricity in applications such as space and remote site power, self-powered appliances, co-generation, and hybrid electric vehicles.

• an automated in-vivo injection and sampling workstation for administering test agents in-vivo, obtaining samples, and preparing samples for analysis using a preprogrammed robotic system.

Advanced Refractory Technologies Inc. (ART)

Buffalo, NY

ART will highlight DYLYN™ diamond-like, tailorable, nanocomposite thin-film coatings that provide wear resistance and adhesion to metals, ceramics, and plastics. Applications include components requiring corrosion/erosion resistance in the automobile, medical, and marine industries; and microelectronic components requiring protection from moisture, chemicals, and ultraviolet radiation.

Applied Material Technologies Inc.

Honeywell Satellite Systems Operation
Santa Ana, CA,

is developing the Control Moment Gyro (CMG) for pointing and attitude control systems in small spacecraft that require lightweight components. The CMG uses Discontinuously Reinforced Aluminum (DRA), a machinable composite material.

Eltron Research Inc.

Boulder, CO

Ceramic Membrane Reactor (CMR) technology promotes partial oxidation reaction of natural gas to produce synthesis gas in applications such as producing higher olefins and liquid fuels, on-site carbon monoxide production as a chemical feedstock, and reduction/removal of toxic emissions from power generation and chemicals processing.

Irvine Sensors Corp.

Costa Mesa, CA,

will exhibit the Serial Infrared Communications (SIRComm™) Receiver that enables infrared wireless point-to-point communication and data transfer between computers, electronic organizers, printers, and other electronic devices that have compatible ports. The SIR2 version is a dual-voltage, low-power analog IC that was commercialized this year.

Martek Biosciences Corp.

Columbia, MD

Docosahexaenoic acid (DHA) is a long-chain, polyunsaturated fatty acid believed to be associated with mental and visual development in infants. Martek has identified strains of microorganisms which produce oils rich in DHA (and arachidonic acid/ARA) and blended them into a mixture known as Formulaid®. Five companies have signed licensing agreements to include Formulaid in their infant formulas.

Material & Electrochemical Research (MER) Corp.

Tucson, AZ,

will highlight carbon-carbon composites for engine components, gas storage on fullerenes, and fullerene nanostructures for lithium battery electrodes.

Merritt Systems Inc.

Merritt Island, FL

MSI has developed a whole-arm obstacle-sensing system for use on articulated robot manipulators that uses a flexible sensor skin with space sockets and up to 1000 smart sensor modules. The skin provides power distribution and fault tolerant communication between a PC controller and the sensor modules, and can be cut to fit most robots.

Natural Fibers Corp.

Ogallala, NE

Syriaca (also known as common milkweed) has been commercialized using proprietary seed and production technology. The company processes harvested pods in patented processing equipment to produce syriaca raw materials for the manufacture of Ogallala Down comforters, pillows, and other syriaca floss products.

Product Development Assistance (PDA) Inc.

Midlothian, VA,

will highlight its patented Electrically Enhanced Filtration (EEF) technology that uses a high-flow, low-pressure-drop filter that is electrostatically enhanced to high efficiency, while retaining the low-pressure drop and advantages of the base filter material. The technology kills bacteria and is designed for use in cleanrooms and other contamination-sensitive environments.

Ribbon Technology Corp.

Gahanna, OH

RibTec has developed a method of direct casting to produce titanium aluminide–a critical material for the development of aircraft and space vehicles–in strip foil form. In foil form, the material can be fabricated using honeycomb cores and foil face sheets to provide lightweight structural components used in turbine engines, rocket engines, and other structural applications.

Silicon Mountain Design Inc.

Colorado Springs, CO,

will present a multiple output silicon/GaAs hybrid imaging device.

Stress Photonics Inc.

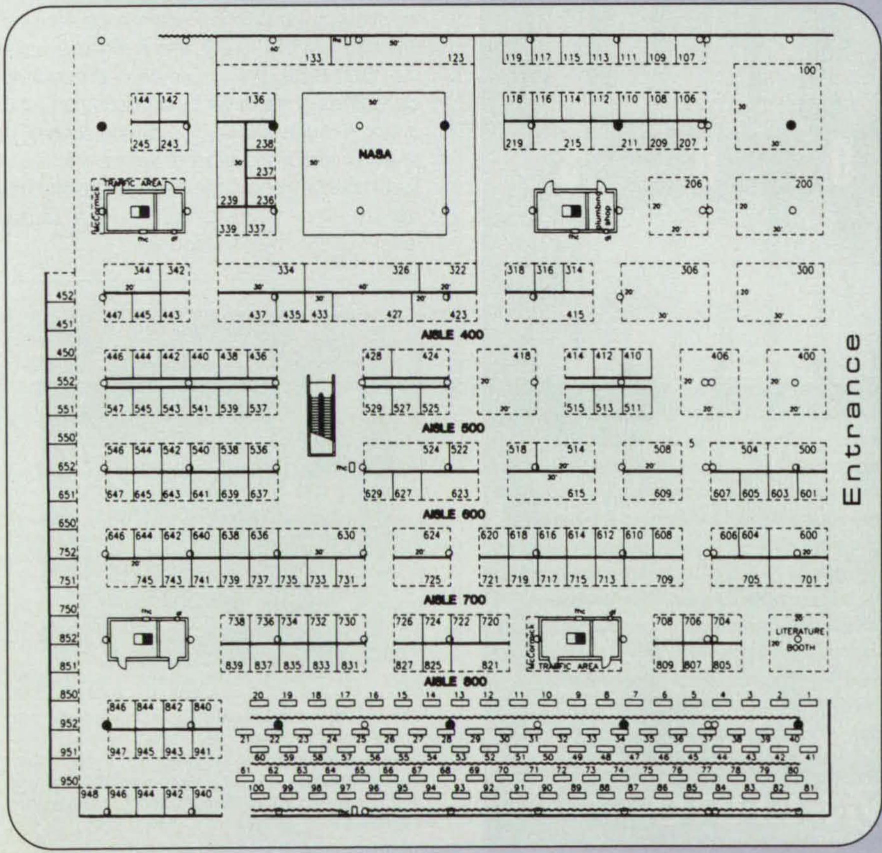
Madison, WI,

will exhibit the DeltaTherm 1000 infrared camera system that "sees" stress in a structure caused by dynamic loading. Based on the Thermoelastic Effect, the camera uses infrared detectors to sense slight temperature changes that occur when a structure is stressed.

Transcience Associates Inc.

Evanston, IL,

will display the MicroFlo™ rubber-geared pump at the heart of a robotic pipettor/dispenser system for loading and dosing of microliter volumes into multiwell microplates. The gear pump eliminates the roller bearing, clamps, and plastic tubing neces-



sary to produce the peristaltic action that results in fluid flow.

TRICOR Systems Inc.
Elgin, IL

TRICOR developed the TSI-151A Airborne Surveillance Imaging System (ASIS) to provide the US Navy with the capability to perform long-range, EO surveillance of coastal installations and surface vessels beyond the threat range. The system incorporates commercial, off-the-shelf components.

Triton Systems Inc.
Chelmsford, MA

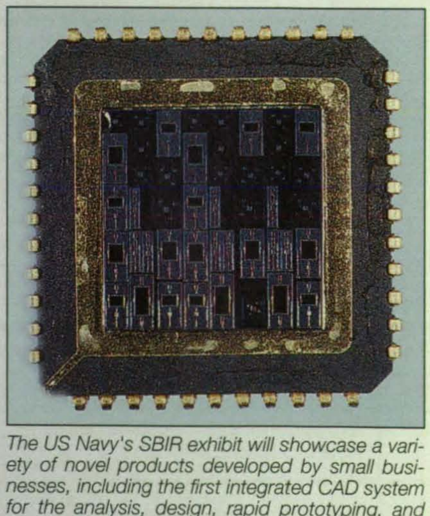
Six products based on a new class of polymers developed at NASA Langley called poly(arylene ether benzimidazole)s, or PAEBI, are currently under development by Triton. The polymers exhibit a combination of properties—including resistance to atomic oxygen erosion—that make them useful in space, electronics, and high-pressure liquid separation applications.

Unitech Research Inc.
Madison, WI

VideoTact is a graphical computer user interface for the blind that consists of an abdominally-worn electrode array and a computer hardware/software interface. The system provides access by blind computer users to computer graphics information.

Virtual Worlds Inc.
Rolling Meadows, IL,

will present the Driving Performance Analysis System, a virtual-reality driving-world simulator that tests the information-processing capabilities of the driver by simulating on-road driving through field-of-view driving scenes. A steering wheel and other driver input interactively control the images displayed as the car moves. The simulator provides a digital record of the driver's responses.



The US Navy's SBIR exhibit will showcase a variety of novel products developed by small businesses, including the first integrated CAD system for the analysis, design, rapid prototyping, and manufacture of MEM devices and ICs (developed by Intellisense Corp.).

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Commercial Technology Office of the sponsoring NASA center (see page 14).

Gas-Sensing Flip-Flop Circuits

New gas-sensing detectors are being developed that discriminate among different gas species. Potential applications include monitoring homes and industrial facilities against dangerous gases, environmental monitoring, and chemical processing. (See page 48.)

Brake Stops Both Rotation and Translation

The new brake is fast and convenient. A single actuator energizes the braking actions against both rotation and translation. Developed originally to position model aircraft in wind tunnels, the brake, for example, can be adapted to cameras on tripods. (See page 114.)

Polyimides Made From PDMDA

A greater degree of transparency and lower dielectric constants make these polyimides more suitable in electronic and optical applications; e.g., as insulating materials on wires and protective films on solar photovoltaic cells.
(See page 90.)

Electronic Ambient-Temperature Recorder

Developed originally for recording temperatures of instruments and life-science experiments in space or at high altitudes, this unit can be used, for example, to record the storage temperature of perishables over extended periods of time to indicate possible spoilage.
(See page 58.)

Ultra-High-Density Ferroelectric Memories

The proposed memory devices would use thin dielectric films to store data in the form of electric polarization. Storage capacity in an all-optical version would approach 1 terrabit/cm^2; an optoelectronic version is expected to exceed 1 gigabit/cm^2. Operating life is estimated to be 10 years. (See page 60.)

Portable Immune-Assessment System

Incorporating a few specific fluorescent reagents, this system can identify immune-cell dysfunction, toxic substances, buildup of microbial antigens, or microbial growth. The system can make immediate onsite evaluation of a person's health or contamination of the environment. (See page 121.)

FROM SUPERCOMPUTER TO PC

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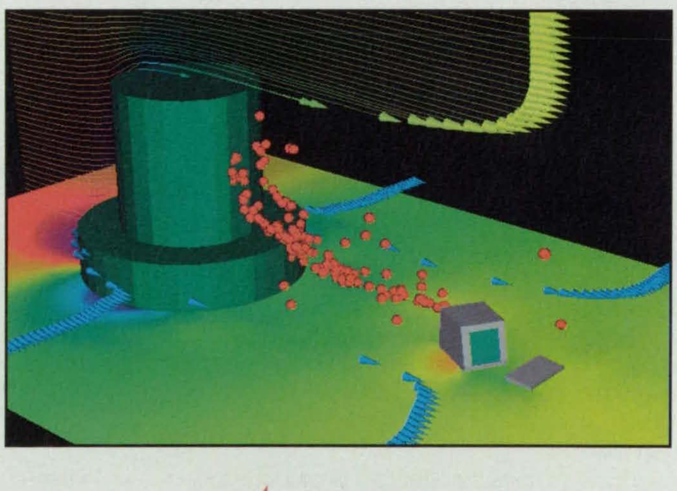

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Fiber-Optic/Photoelastic Flow Sensors

Simple, rugged, lightweight transducers detect periodic vortices.

Lewis Research Center, Cleveland, Ohio

Fiber-optic-coupled transducers are being developed to measure flows over wide dynamic ranges and over wide temperature ranges in severe environments. They could be used, for example, to measure flows of fuel in advanced aircraft engines. The feasibility of these sensors has been demonstrated in tests of a prototype sensor in water flowing at various temperatures and speeds. Fiber-optic-coupled flow transducers are particularly attractive for aircraft applications because optical fibers are compact, are lightweight, and make possible the transmission of sensor signals at high rates with immunity from electromagnetic interference at suboptical frequencies.

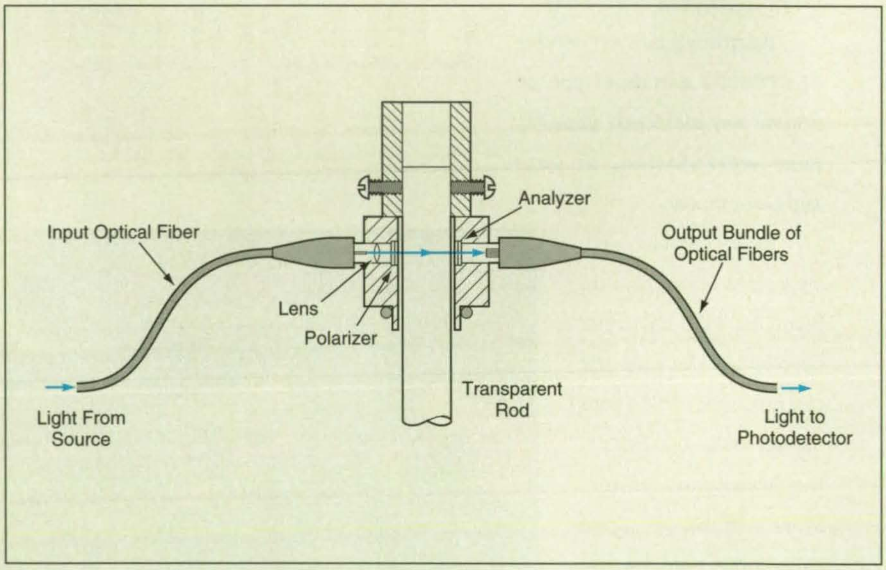
The developmental flow sensors can be designed to exploit fully the ruggedness of fiber optics: unlike in some other sensor systems with fiber-optic coupling, there are no delicate electronic components at the transducer locations because the principle of operation of these flow sensors does not involve optical-to-electronic or electronic-to-optical conversions within the flow transducers. Instead, these sensors utilize optical-to-optical conversion via the photoelastic effect.

The developmental sensors are based partly on the established concept of the vortex-shedding flow sensor: A bluff body — typically a rod — is placed in the stream to be measured, oriented transversely to the direction of flow. Vortices form on the downstream side of the body. At any speed within a wide range of speeds, the vortices detach alternately from opposite downstream edges or corners of the body in a regular series and travel downstream in what is called a "Karman vortex street." The vortices can be sensed at a location close to and downstream of the bluff body by use of a rod equipped with a strain sensor to measure the periodic load applied to the rod by the passing vortices. The frequency of passage of the vortices is directly proportional to the speed of flow, the factor of proportionality being a function of the density and viscosity of the fluid and thus a function of temperature.

In a transducer of the present type, the downstream sensing rod (see figure) is made of a transparent material. Light from a light-emitting diode or other source is brought in by an input optical fiber, is focused by a lens, and passes through a polarizer. The linearly polarized light that emerges from the polarizer passes through the rod at a location near its clamped end, where the bending stress induced by the passing vortices is greatest. After emerging from the rod, the light impinges on a second polarizer (analyzer) with polarization perpendicular to that of the first polarizer. The portion of light that survives passage through the analyzer enters an output bundle of optical fibers, which transmits the light to a photodetector.

In the absence of stress in the rod, the polarization of light is not changed by passage through the rod; the light incident on the analyzer remains polarized perpendicularly to the polarization axis of the analyzer and consequently little or no light passes through the analyzer. When the rod is stressed, the photoelastic effect in the rod material causes a change in the polarization of the light passing through, so that some of the light becomes polarized along the polarization axis of the analyzer, giving rise to an increase in light transmitted to the photodetector. The optical power that passes through to the photodetector is proportional to $[\sin(k\sigma)]^2$, where σ is the stress in the rod and k is a constant of proportionality that depends on the rod material.

The fundamental frequency of fluctuation of the photodetector output is thus proportional to the rate of flow. Signal-processing circuitry connected to the photodetector measures this frequency. The frequency reading can be digitized and processed, along with an ancillary temperature reading, by an algorithm that corrects for the effect of temperature on the factor of proportionality between the vortex-passage frequency and the rate of flow.



The Transparent Rod Is Stressed by passing vortices shed by an upstream body. The stress in the rod is measured via the photoelastic effect. The frequency of fluctuation light traveling to the photodetector is proportional to the vortex-passage frequency.

This work was done by Laurence N. Wesson, and Nellie L. Cabato of Aurora Optics, Inc., and Edward F. Brooks, private consultant, for **Lewis Research Center**. *For further information,* ***write in 77*** *on the TSP Request Card. LEW-15536*

Embedded Temperature-Change Sensors

These sensors could help to prevent overheating of electronic components.

NASA's Jet Propulsion Laboratory, Pasadena, California

Transducers sensitive to rates of change of temperature would be embedded in integrated circuits and discrete electronic components that could be damaged by overheating, according to a proposal. These temperature-change sensors would be used to detect the onset of rapid heating and to trigger shutoffs of power or other corrective actions before temperatures could rise beyond safe limits (see figure). In comparison with older electronic temperature sensors that operate at the system and circuit-board levels, these sensors would respond faster and more reliably to incipient overheating because they would be in direct thermal contact with the vulnerable circuit elements.

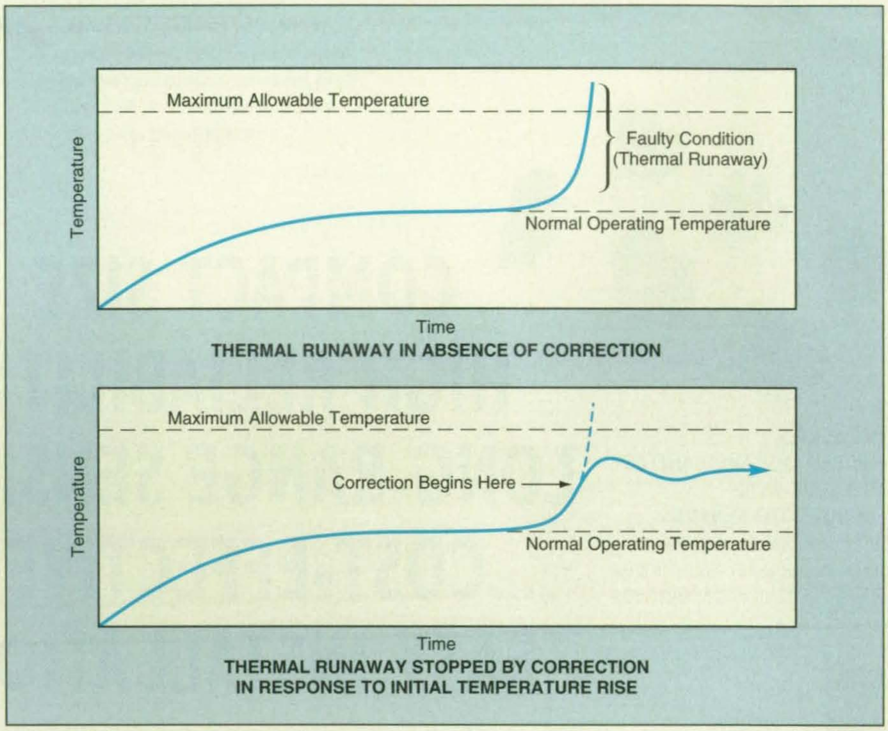
The proposed sensors would be low-thermal-inertia, microscopic capacitors, the dielectric layers of which would be thin films of such perovskite materials as lead lanthanum zirconate titanate. These materials are ferroelectric and they exhibit the pyroelectric effect, meaning that a capacitor made with such a material generates a voltage proportional to the rate of change of temperature. The temperature-change sensors and the associated corrective or safety-shutdown circuitry could be fabricated directly on silicon integrated-circuit chips, along with the circuits to be protected against overheating: the integration of the sensing and protective circuitry with the other circuitry should result in a significant reduction in the overall area and power consumption of integrated circuits.

This work was done by Sarita Thakoor, Anil Thakoor, and Dan Karmon of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 44*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19405, volume and number of this NASA Tech Briefs *issue, and the page number.*



Thermal Runaway in a typical power semiconductor device is a regenerative self-heating effect that can quickly lead to overheating and destructive loss if not interrupted. A temperature-change sensor embedded in the device would respond to the initial temperature rise by generating a signal that would trigger corrective action to prevent damage to the device.

Gas-Sensing Flip-Flop Circuits

The voltages of metastable states would vary with exposures of gas-sensitive resistors.

NASA's Jet Propulsion Laboratory, Pasadena, California

Gas-sensing integrated circuits that consist largely of modified static random-access memories (SRAMs) are undergoing development, building on experience gained in the use of modified SRAMs as radiation sensors. Each SRAM memory cell includes a flip-flop circuit; these sensors exploit a metastable state that lies between the two stable states (corresponding to binary logic states) of a flip-flop circuit.

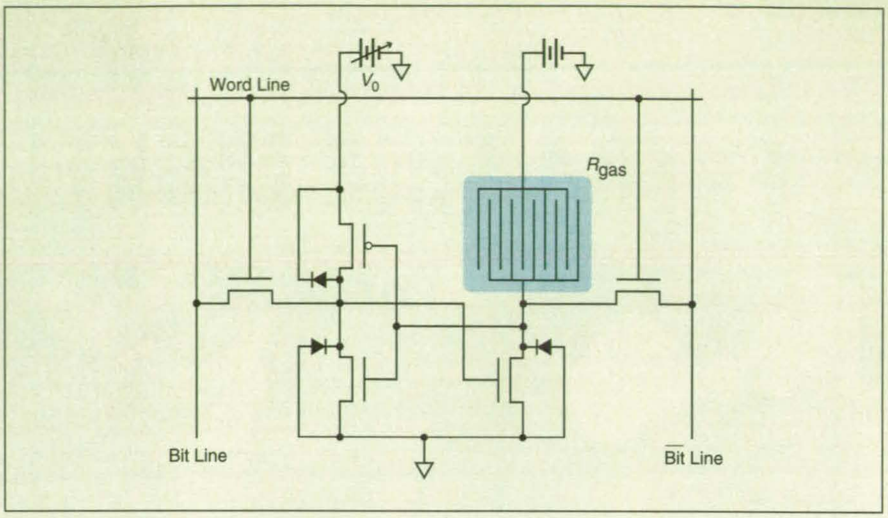
The operation of a gas sensor of this type is based on the fact that the voltage of the metastable state at a suitably chosen node of a flip-flop circuit depends on the value of a resistor in the circuit. This resistor could be designed and fabricated so that its resistance would vary with the amount of a selected gas that it had absorbed or adsorbed from the atmosphere. Inasmuch as the absorbed or adsorbed amount would be related to the concentration of the gas in the atmosphere, the voltage of the metastable state would be indicative of this concentration.

A gas-sensing resistor could be fabricated as a pair of interdigitated metal electrodes in contact with a film of sensing material. Candidate sensing materials include doped tin dioxide and both metal-substituted and metal-free phthalocyanines. The electronic properties of these materials have been well characterized; these materials have been found to be suitable for detection of, and discrimination among, a number of gas species, including O_2, CO, CO_2, CH_4, NO, NO_2, H_2O, NH_3, and N_2H_4.

The figure shows a typical complementary metal oxide/semiconductor (CMOS) modified SRAM cell designed

according to this concept. The gas-sensing resistor (R_{gas}) would be connected between one of the inverters of the flip-flop and a power supply of constant voltage V_{DD}. The other inverter would be connected to a source of variable offset voltage (V_o). The voltage of the metastable state would be determined by varying and measuring V_o and noting the value of V_o at which the circuit flipped spontaneously from one logic state to another.

In principle, a gas sensor could contain a single flip-flop circuit. However, the use of a SRAM instead of a single flip-flop would make it possible to take advantage of the statistical distribution of metastable-state voltages among the numerous memory cells. This would be accomplished by operating in either of two modes. In one mode, V_o would be varied to obtain a spontaneous-flip curve (a plot of the number of cells that have flipped as V_o was lowered from an initial value to a present value). The parameters of the spontaneous-flip curve would depend on the statistical distribution of R_{gas} values and of other circuit parameters; the parameters of the spontaneous-flip curve could therefore be related to the concentration of gas via the dependence of the R_{gas} values on this concentration. The other operating mode would be based on similar concepts, but in this mode, V_o would be held constant and the number of flipped cells would be counted and related to the concentration of gas.



The Value of R_{gas} Would Vary with the amount of gas it had absorbed or adsorbed, giving rise to a corresponding variation in the value of V_o at which the logic state of the circuit would flip spontaneously.

Another advantage of the use of modified CMOS SRAMs is that signal-detecting circuits and analog-to-digital converters can be incorporated into the flip-flop or memory cells to provide digital outputs that can be utilized readily by a computer. Furthermore, the modified RAMs can be made by conventional CMOS fabrication techniques, with simple addition of the gas-sensing resistors.

This work was done by Martin G. Buehler, Brent R. Blaes, Roger Williams, and Margaret A. Ryan of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 42*** *on the TSP Request Card. NPO-19389*

Optical-Fiber Fluorosensors With Polarized Light Sources

Transverse polarization would increase sensitivity.

Langley Research Center, Hampton, Virginia

The chemiluminescent and/or fluorescent molecules in optical-fiber fluorosensors would preferably be oriented with their light-emitting dipoles along the transverse axis, according to a proposal. In comparison with an otherwise identical optical-fiber fluorosensor in which the same number of dipoles were oriented randomly, a sensor of the proposed type would capture a greater fraction of the chemiluminescence or fluorescence and transmit it to a photodetector; that is, it would be more sensitive.

The basic principles of optical-fiber fluorosensors were described in "Making Optical-Fiber Chemical Sensors More Sensitive" (LAR-14525), *NASA Tech Briefs*, Vol. 17, No. 3 (March 1993), page 77; "Improved Optical-Fiber Chemical Sensors" (LAR-14607), *Laser Tech Briefs*, Vol. 2, No. 2 (Spring 1994), page 61; and "Improved Optical-Fiber Temperature Sensors" (LAR-14647), *Laser Tech Briefs*, Vol. 1, No. 1 (Septem-

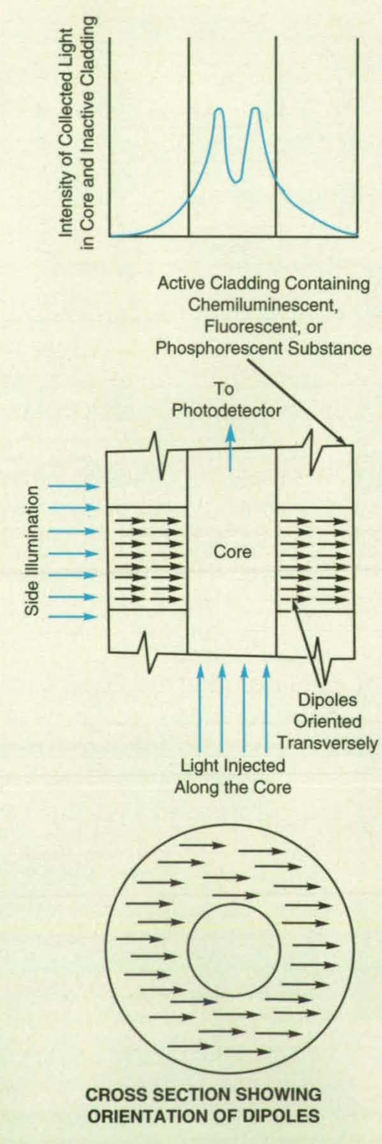


Figure 1. This **Optical-Fiber Fluorosensor** would contain radiating dipoles oriented along an axis perpendicular to the cylindrical axis. In other respects, it would be similar to prior optical-fiber fluorosensors in which the dipoles are oriented randomly.

ber 1993), page 54. As explained in more detail in those articles, a typical optical-fiber fluorosensor would include a sensing length in which the cladding or the core of the fiber would contain molecules that fluoresce or chemiluminesce in the presence of a substance to be detected or would contain molecules that change their fluorescence with different temperatures. For cladding sources, part of the fluorescence, chemiluminescence, or phosphorescence would be coupled, via the evanescent-wave interaction, into the core and transmitted along the core to a photodetector.

Figure 1 shows the proposed optical-fiber fluorosensor with transversely oriented dipoles. As in the case of randomly oriented dipoles, illumination to excite fluorescence could be supplied from the side or by injection along the core with evanescent-wave absorption by the cladding.

For the purpose of comparison among different designs, a principal figure of merit is the power efficiency, which is the ratio between the power of the light captured by the core toward the photodetector and the total power of light emitted by the dipoles (which is the sum of the power radiated away by the fiber and the power captured by the core in both directions). The power efficiency can be calculated by using the exact field solution of an optical fiber and solved for given distribution of radiating dipoles. As shown in the example of Figure 2, the calculated power efficiency is greater when the dipoles are oriented transversely.

This work was done by Claudio O. Egalon of Analytical Services and Materials, Inc., and Robert S. Rogowski of **Langley Research Center.** *For further information,* ***write in 163*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-14652.

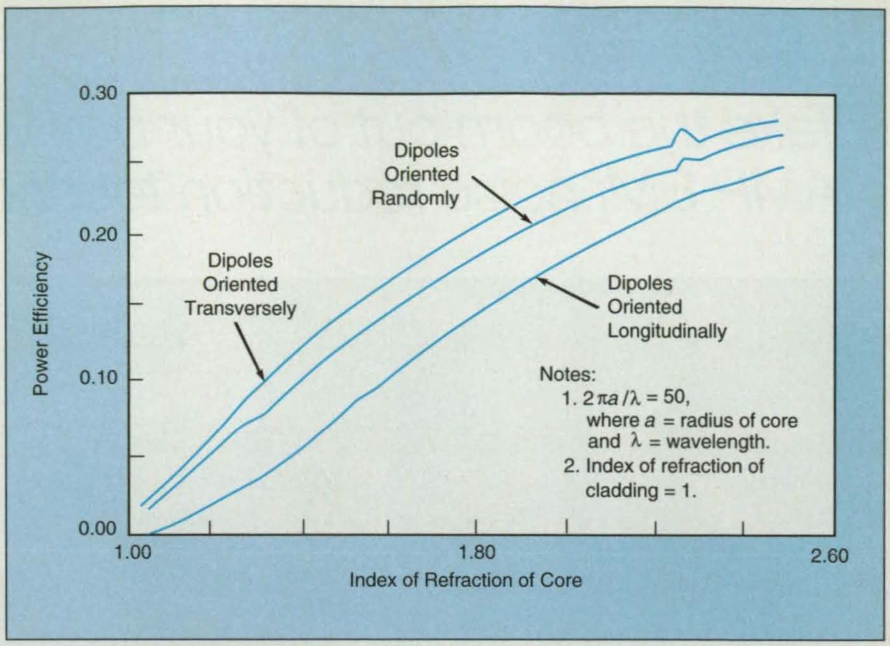


Figure 2. The **Power Efficiency** of an optical-fiber fluorosensor was calculated by using the exact field solution of an optical fiber.

Measuring Thicknesses With In Situ Ultrasonic Transducers

Ultrasonic transducers would be semipermanently attached to a workpiece.

Marshall Space Flight Center, Alabama

Several pulsed ultrasonic transducers would be attached to a workpiece for measurement of changes in the thicknesses of the workpiece at the transducer locations during grinding and polishing, according to a proposal. Once attached, each transducer would remain attached at its original position until all grinding and polishing operations were complete.

In a typical application, the workpiece would be a glass or ceramic blank destined to become a component of an optical system. Heretofore, it has been common practice to measure thicknesses of such a workpiece at different positions by use of a single ultrasonic transducer, which is placed on the workpiece at each measurement location in sequence. The nonrepeatability of placement inherent in this practice has

(continued on page 56)

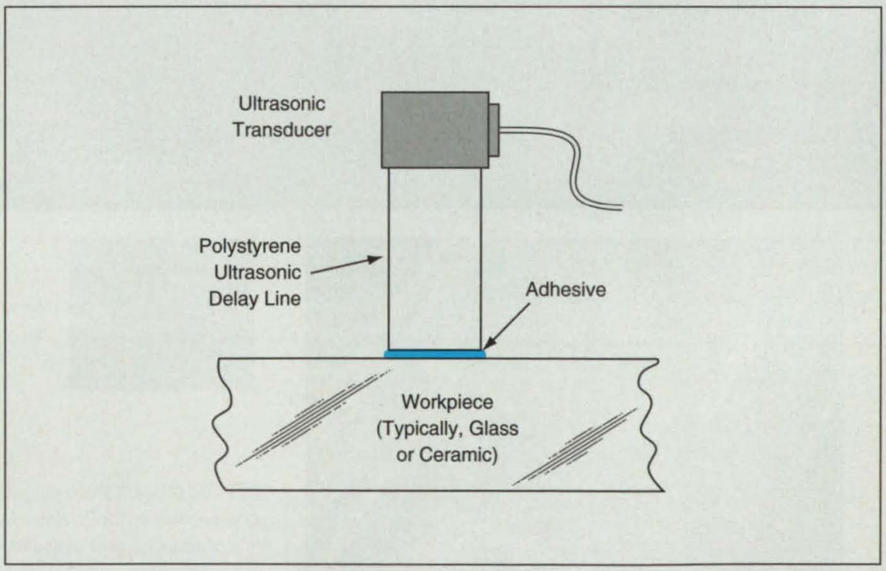
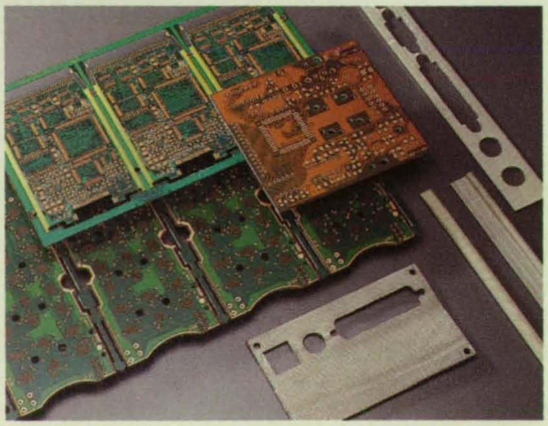
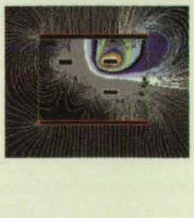


Figure 1. Each **Ultrasonic Transducer** would be attached mechanically to a commercial polystyrene delay line, which would be cemented to the workpiece with a thin film of acoustically conductive adhesive.

Take the boom out of your box with AMP EMI noise reduction technology.





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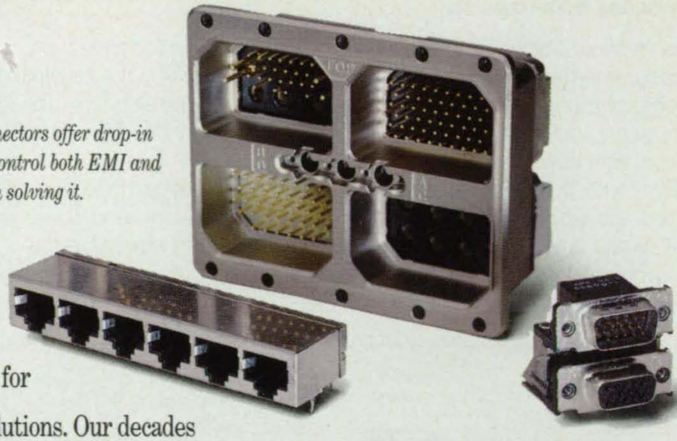

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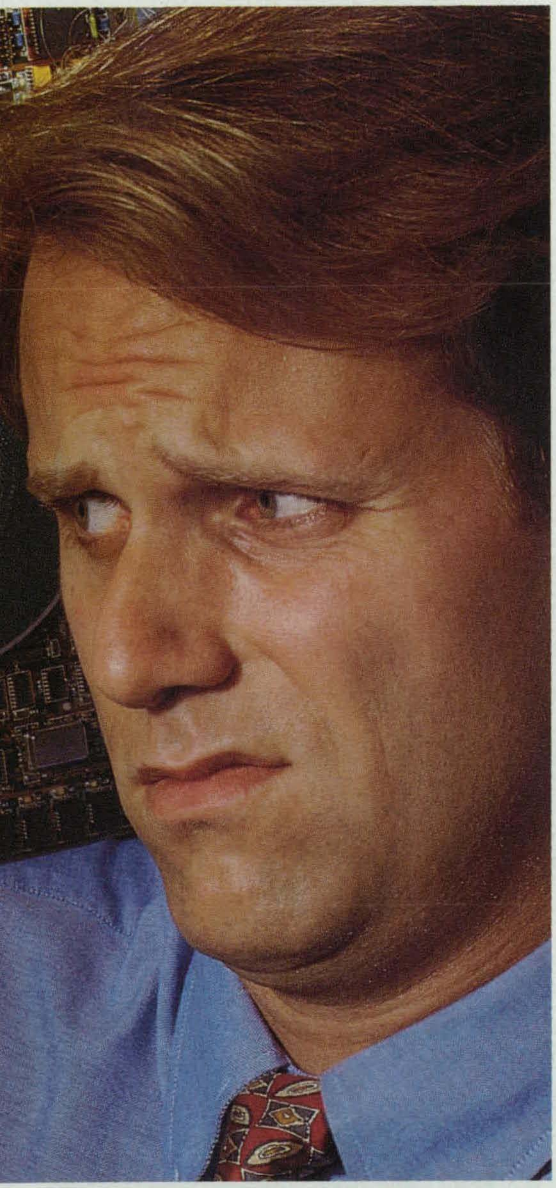

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QuietBoard is another AMP EMI innovation. This unique board-coating technology eliminates the frustration of failing emissions certification, without resorting to multilayer ground planes. All at up to 25% real cost savings over other board-level fixes.

When it comes to filtered connectors, the industry's widest performance range – from ferrite through distributed element – and most respected core product technology are at AMP. Our QuietLine drop-in, replacement filtered connectors and shielded cable assemblies can be found almost anywhere there's an EMI- sensitive application.

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At AMP, we solve EMI problems while providing you with increased design flexibility, reduced time to market and peak system performance. And that's something worth turning up the volume about.

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AMP

For More Information Write In No. 503

(continued from page 53)

been a source of large errors in thickness measurements. By using several transducers and cementing them at the measurement positions (see Figure 1), one would eliminate placement errors.

Figure 2 illustrates a computer-controlled ultrasonic measurement system that would implement this concept. The ultrasonic transducers would be connected via a multiplexer to a commercial ultrasonic-testing circuit. Under computer control, the multiplexer would connect the transducers to the instrument in sequence. The ultrasonic-testing circuit would thus produce thickness readings for the various transducer locations in sequence, and these readings would be sent to the computer.

Such a system was implemented for the grinding and polishing of the AXAF mirror elements. Eight sites per optic were multiplexed. The average rms repeatability was 0.19 µm, about 10 parts per million for the thicknesses measured.

This work was done by Daniel E. Dunn and Joseph R. Cerino of Hughes Danbury Optical Systems, Inc., for **Marshall Space Flight Center**. *For further information,* ***write in 81*** *on the TSP Request Card. MFS-28892*

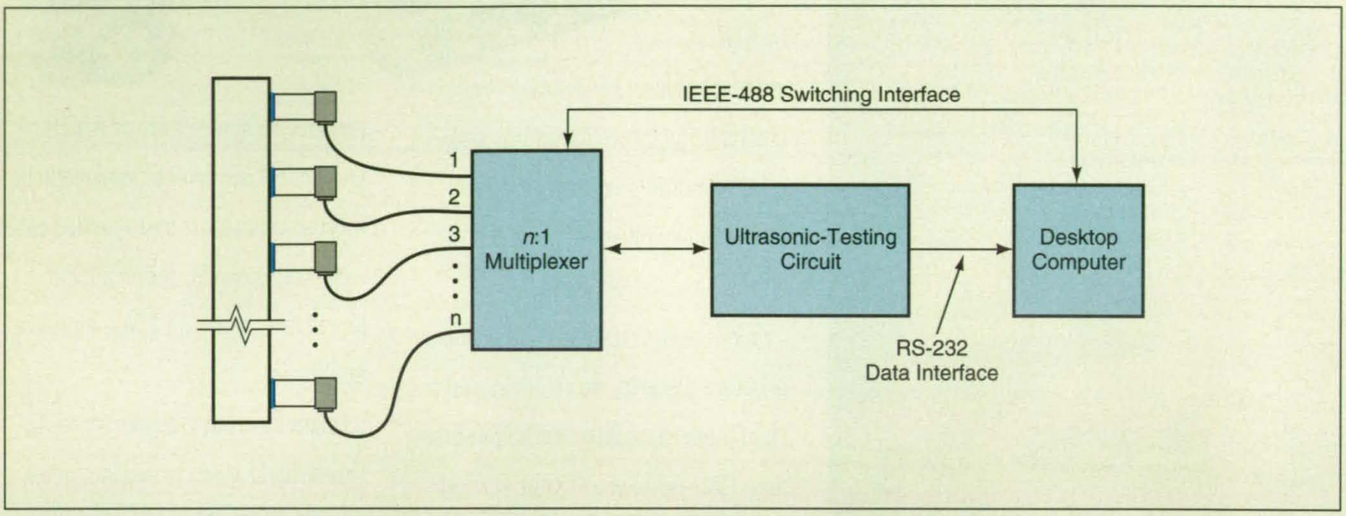
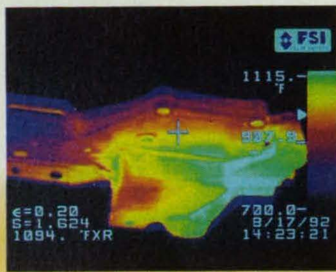


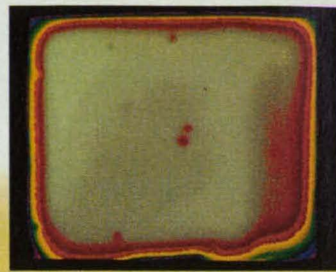
Figure 2. The **Computer-Controlled Ultrasonic Testing System** would take readings via the semipermanently bonded ultrasonic transducers and map out changes in the thickness of the workpiece.

Engine development

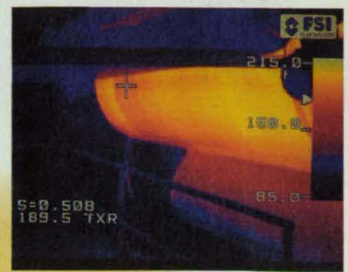
Measure casting temperatures



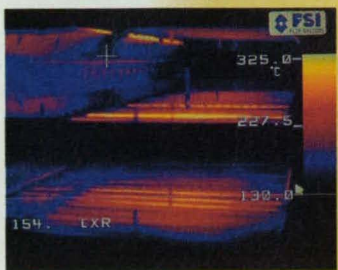
Defects in composite materials



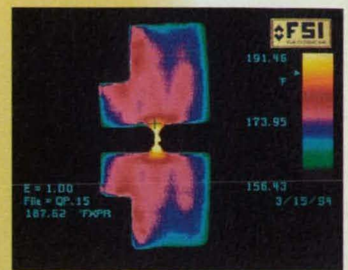
Moisture content in paper



Monitor soldering processes



Injection mold performance



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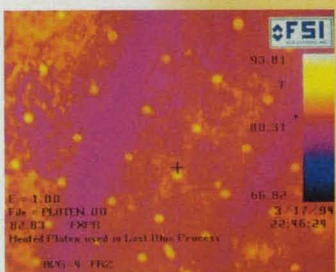
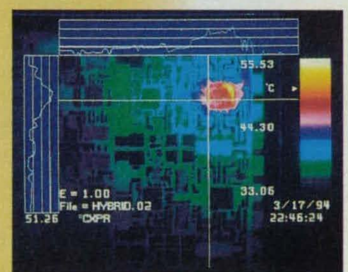
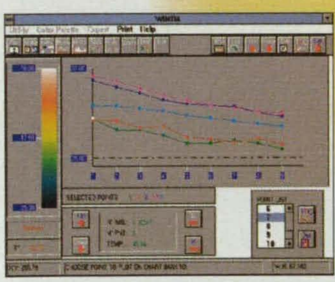


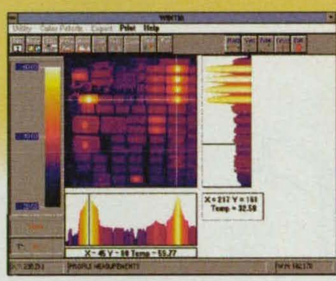
Evaluate wax injection presses



Hybrid circuit failure analysis



Analyze trend data



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Electronic Components and Circuits

Electronic Ambient-Temperature Recorder

Data are logged in an electronic memory for later display on a computer.

Ames Research Center, Moffett Field, California

An electronic temperature-recording unit stores data in its internal memory for later readout. It records temperatures from -40 to +60 °C at intervals that range from 1.875 to 15 minutes. With all four of its data channels operating at 1.875-minute intervals, the recorder can store at least 10 days' data. For only one channel at 15-minute intervals, the capacity extends to up to 342 days' data. Two lithium cells can supply power to the unit for about 2 years (although the conservatively rated replacement interval is 1 year).

The unit was developed for recording temperatures of instruments and life-science experiments on satellites, the space shuttle, and high-altitude aircraft. It is adaptable to such terrestrial uses as recording temperatures of perishable goods during transportation and of other systems or processes over long times. It can be placed directly in the environment it is to monitor.

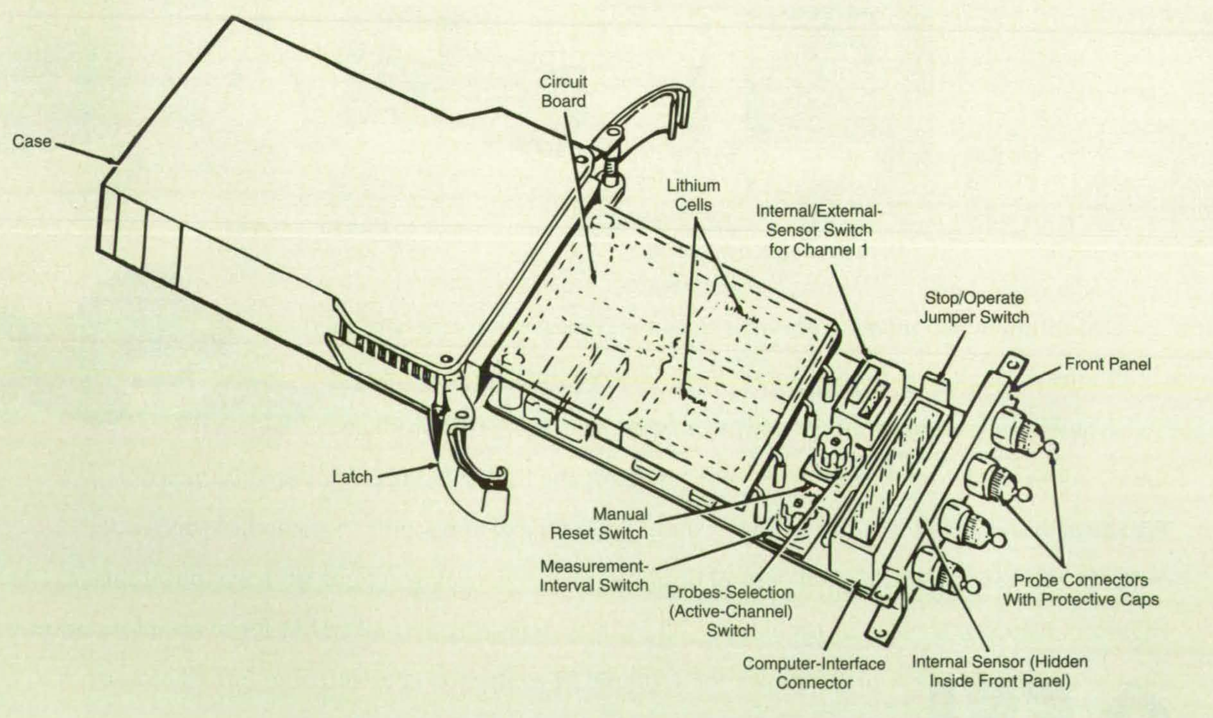
The unit (see figure) is light and compact: it weighs 135 grams and is housed in a 23- by 41- by 86-millimeter case. Connectors on the front of the housing accept as many as four temperature probes, one for each data channel. In addition, an internal sensor measures the ambient temperature; it can be used as input for channel 1. Switches inside the case are used to select the measurement interval and the number of active channels.

Temperature readings are digitized to 8 bits and stored in a 32 KB random-access memory (RAM). The data are read out by a desktop computer, which processes them for display in tabular and graphical form. The RAM is then reset for further measurements.

In addition to the RAM, the unit contains an oscillator/counter timing section, an input analog section, and an analog-to-digital converter (ADC). The major components of these sections are low-power complementary metal oxide/semiconductor (CMOS) integrated circuits. To conserve energy, the input analog section and the ADC, which draw 7 mA, are switched on only during measurement. The other ICs and the RAM draw about 30 μA in standby mode between measurements.

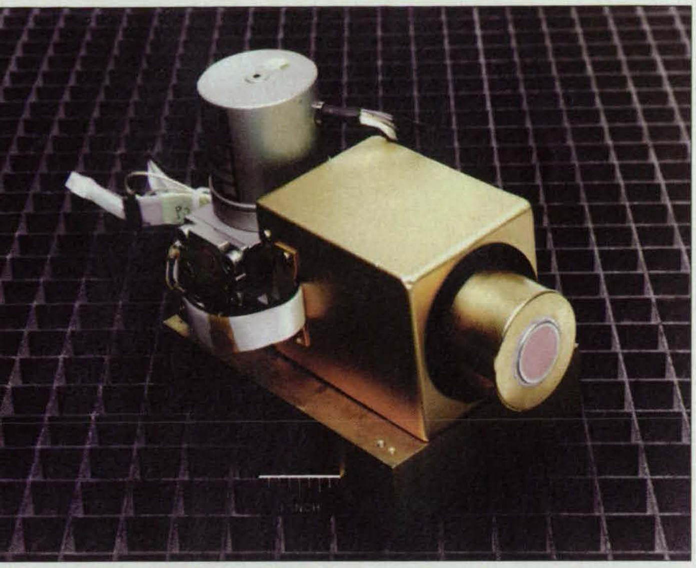
The measurement temperature range can be changed by changing offset and feedback resistors. The narrower the range, the finer the resolution. For the design range, which is 100 °C wide, the resolution is 0.4 °C.

This work was done by Larry Russell and William Barrows of **Ames Research Center**. *For further information,* ***write in 70*** *on the TSP Request Card.*
ARC-13220



Lithium Cells and Circuitry are on a board in the instrument housing. The board can be withdrawn for setting of switches. Probe connectors are accessible from the front of the housing.

Infrared Engine



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System Description:

The **Infrared Engine** uses our full television resolution 640 X 480 pixel Platinum Silicide (PtSi) MOS IRFPA mounted in a Stirling cycle cooled Dewar, with a f/1.5 baffled cold shield, and a cooled optical filter. The engine has complete drive and analog video electronics.

The **Infrared Engine** is extremely compact for use on gimbal systems and provides analog video at RS170 scan rates. A key capability is the eight IRFPA operating integration modes that can be selected for electronic shuttering (or an option can be added that will allow higher frame rate operation).

Technical Characteristics

640 X 480 Pixel PtSi FPA

- 24 (H) X 24 (V) micron pixels
- 50% fill factor
- No blooming, no lag, no transfer smear
- 3-5 μm spectral band
- NEDT = 0.15 (typical)

Cool Down Time: 12 minutes to first image

Outputs:

- Non-composite RS170 video
- Composite sync
- Linesync
- Vertical blanking
- Pixel clock
- FPA temperature voltage output

Controls:

- Commandable integration time (63μs to 33ms)

Dimensions (mm)

- Camera head 77.72 (H) X 64.0 (W) X 156.72 (L)
- Electronics Box 23.88 (H) X 87.12 (W) X 116.08 (L)

Total weight: 1.2 kg

Applications

- Air to air/ground target tracking
- Personnel perimeter control
- Ground vehicle observation platform
- Industrial temperature measurement

Environmental Operating Conditions (Design Objectives)

- Temperature: -30°C to 60°C
- Performs within specification under typical random vibration environment of 6G (rms)

Options

- Frame-rate to 1KHz
- 12-bit video processor

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Ultra-High-Density Ferroelectric Memories

Features would include fast input and output via optical fibers.

NASA's Jet Propulsion Laboratory, Pasadena, California

Memory devices of a proposed type would include thin ferroelectric films in which data would be stored in the form of electric polarization. Assuming that one datum could be stored in a region as small as a polarization domain, the sizes of such domains would impose the upper limits on achievable storage densities. These limits would approach 1 terabit/cm^2 in all-optical versions of these ferroelectric memories and would exceed 1 gigabit/cm^2 in opto-electronic versions. These memories are expected to exhibit operational lives of about 10 years, input/output times of about 10 ns, and fatigue lives of about 10^{13} cycles.

In an all-optical version, both writing and readout would be performed at high speed by use of beams of light directed through optical fibers to the ferroelectric film. The small diameters of the fibers and the near-field optical effects at their tips would provide the resolution needed to achieve high densities in both writing and reading data. On the basis of previous experiments in near-field fiber-optic illumination and readout, it appears that the resolution of a readout beam could be as fine as 12 nm.

Writing would be done at wavelengths corresponding to photon energies greater than the bandgap of the ferroelectric material. Writing would rely on changes of the index of refraction of the ferroelectric material, which would be birefringent. This writing process would consume much less energy than is consumed in other techniques of near-field magneto-optical recording. Thus, a memory of this type would consume less power.

The polarization of any given domain produced by the writing process would affect the properties of the light reflected from that domain. Readout would be effected at wavelengths corresponding to photon energies less than the bandgap of the ferroelectric material. Thus, readout would be nondestructive; that is, it would not alter the polarization of the spot illuminated by the readout beam.

This work was done by Sarita Thakoor of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 5*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19265, volume and number of this NASA Tech Briefs *issue, and the page number.*

Miniature Radioisotope Power Source

About the size of a small flashlight, a proposed unit could power small instruments for years.

NASA's Jet Propulsion Laboratory, Pasadena, California

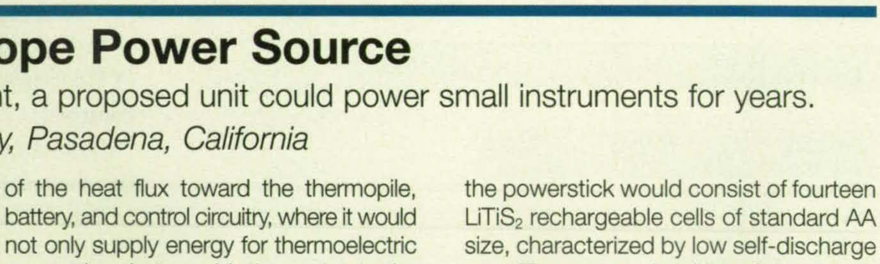
A proposed miniature power source would generate electricity for years without addition of fuel or dependence on sunlight. Called the powerstick, it would be relatively inexpensive, lightweight, and rugged in comparison with other radioisotope thermoelectric generators that have been designed in recent years. The powerstick could supply power to small vehicles or scientific instruments in remote locations on Earth or in outer space. Some envisioned uses include Mars miniature rovers and monitoring equipment for toxic or nuclear storage sites.

The powerstick consists of a radioisotope heater unit, a thermopile made of state-of-the-art thermoelectric material, a rechargeable battery, and control circuitry (see figure). During a full discharge from an initial full charge, the battery could supply 28 W·h of energy (1 A·h at 28 V). The total mass of the power stick would be approximately 380 grams.

The radioisotope heater unit is a spot heater, produced by the U.S. Department of Energy, that contains a relatively small amount of radioisotope fuel and is commonly used on spacecraft. This unit provides 1 W of thermal power. Multilayer thermal insulation would direct most of the heat flux toward the thermopile, battery, and control circuitry, where it would not only supply energy for thermoelectric conversion, but would also maintain the battery and circuitry at the proper operating temperature. The thermopile would convert some of this thermal power to 40 mW of continuous electric power, which would be used to trickle-charge the battery. It would take about one month to fully recharge the battery after full discharge.

The thermopile consists of about 1000 bismuth telluride legs that are 3 cm long and have a square cross section of 1/3 mm on a side. The battery in the powerstick would consist of fourteen $LiTiS_2$ rechargeable cells of standard AA size, characterized by low self-discharge rate. The energy densities of these cells are 120 W·h/kg — about four times that of nickel/cadmium cells. The 28-V output of the battery could be downregulated by a microchip regulator or a dc-dc converter to various lesser voltages with an efficiency of about 85 percent.

This work was done by Artur B. Chmielewski of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 25*** *on the TSP Request Card. NPO-19339*



The **Powerstick Would Generate Electricity** from heat developed in a small radioisotope unit.

VLSI Processor for Vector Quantization

Pixel intensities in each kernel are compared simultaneously with all code vectors.

NASA's Jet Propulsion Laboratory, Pasadena, California

A prototype high-performance, low-power, very-large-scale integrated (VLSI) circuit is designed to perform compression of image data by the vector-quantization method. The circuit contains relatively simple analog computational cells that operate on the direct or buffered outputs of photodetectors grouped into blocks in an imaging array, yielding the vector-quantization code word for each such block in sequence. This scheme exploits the parallel-processing nature of the vector-quantization architecture, with a consequent increase in speed over older purely sequential-processing vector-quantization schemes implemented in software.

For the purpose of vector quantization, the photodetectors in the entire imaging array are grouped into nonoverlapping rectangular blocks called kernels. The pixel intensities or outputs of the photodetectors in each kernel are represented collectively by an m-dimensional vector $\mathbf{x} = (x_1, x_2, \ldots x_m)$, where x_i = the intensity of illumination (or an equivalent detector output) in the ith pixel and m is the number of pixels in the kernel. A set of n code vectors ($\mathbf{c}^1$, $\mathbf{c}^2$, . . . $\mathbf{c}^n$) plus a unique index number (code word) that represents each code vector constitutes a "code book."

The basic vector-quantization process is to (a) find the code vector that approximates $\mathbf{x}$ most closely according to some quantitative measure (e.g., a weighted Euclidean distance $d(\mathbf{x}, c)$ m-dimensional space), then (b) transmit the index number of the code vector, then (c) use the code book in reverse at the receiver to reconstruct an approximation of the pixel intensities in the kernel at the receiver. The advantage of vector quantization is that the index number or code word contains fewer bits than does the corresponding full specification of the pixel intensities in the kernel; that is, the image data are compressed for transmission.

In this vector-quantization scheme, the m analog pixel-intensity values in a kernel are presented simultaneously to an $m \times n$ array of computational cells. The cells are arranged (see Figure 1) so that the ith cell in the jth column represents C_i^j, which is the ith component of the jth code vector. Stated somewhat differently, each column in the array represents one of the code vectors.

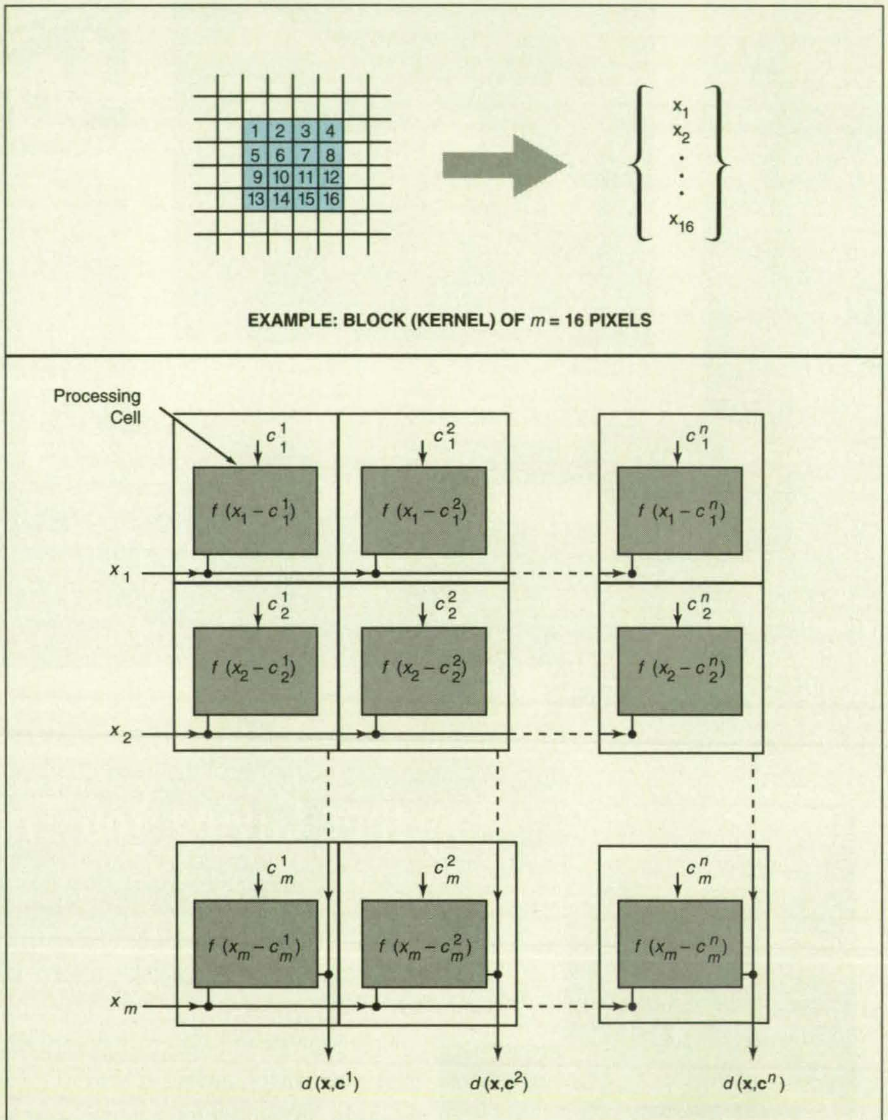
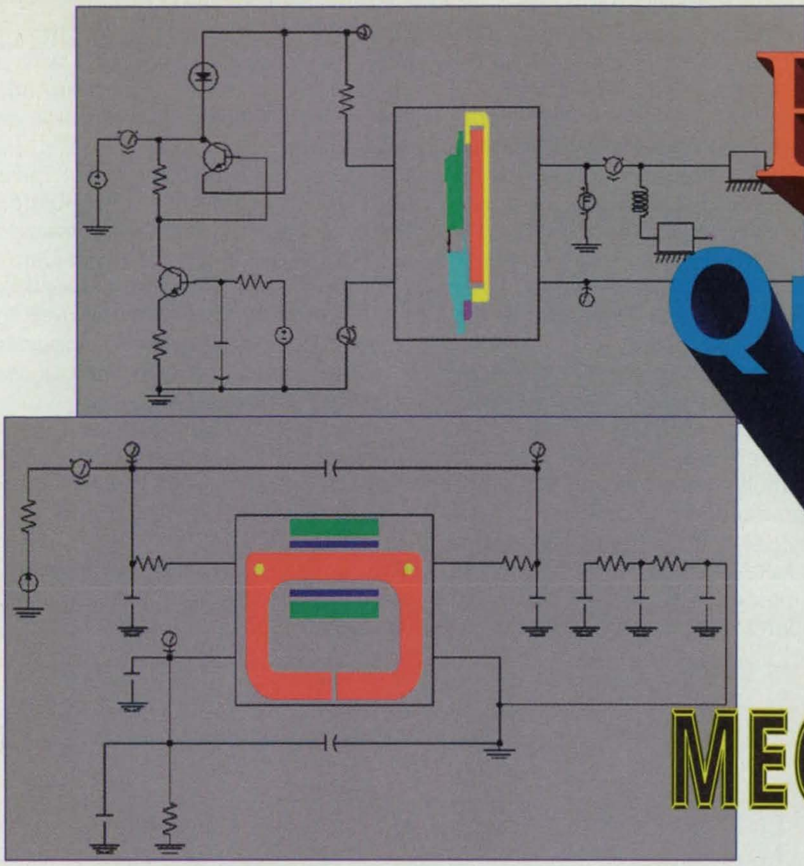


Figure 1. **All m Pixel Intensities** in a kernel are compared simultaneously with the components of n code vectors.

The output of each cell is a quantity proportional to the disparity between the input actual pixel intensity and the corresponding pixel intensity represented by the code vector of the column in which the cell is located. The outputs of all the cells in a column are added, and the sums from all the columns are compared: whichever column yields the smallest sum (representing the least disparity between the input and code vectors) is selected as the "winner," and the code vector for that column is chosen to represent the pixel intensities in the kernel.



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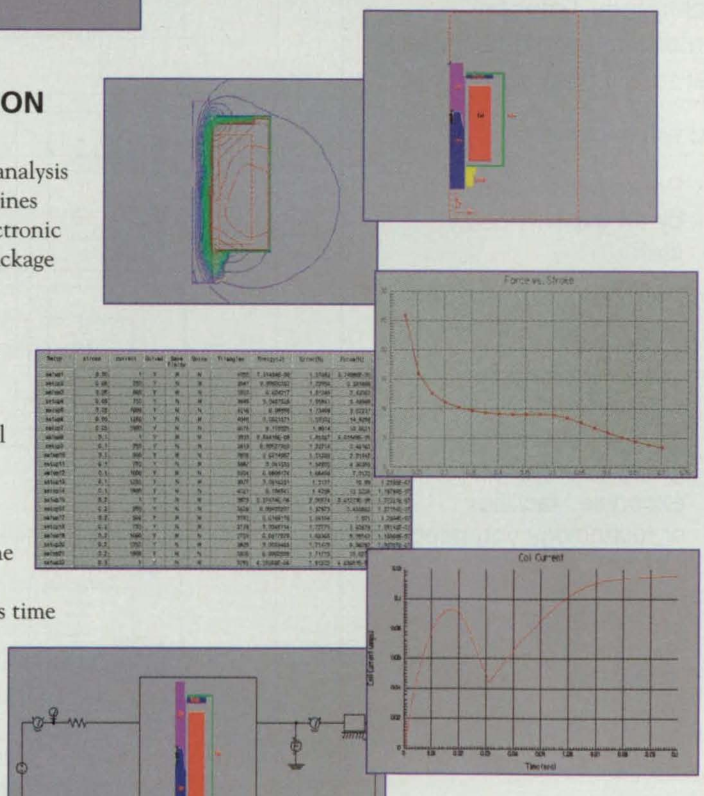

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For More Information Write In No. 526

The prototype VLSI circuit (see Figure 2) implements a vector-quantization scheme with $m = 16$ and $n = 256$. The circuit is fabricated in complementary metal oxide/semiconductor with feature sizes down to about 2 μm. The circuit is programmable in that a set of code vectors can be stored in the array of cells at will. It is also cascadable, so that libraries of several thousand code words can be stored.

An analog voltage that represents the value of C_i^j in each cell is stored via a capacitor-refresh scheme. The circuit includes an address and data demultiplexer, row- and column-address decoders, capacitor-refresh circuitry, 32 analog input lines, and a winner-take-all module with winner-select output lines. This circuit has been found to compress an image of 512 by 512 pixels in 0.5 second — about 400 times as fast, and with a fraction of the power (milliwatts) and cost of a software implementation on a computer.

This work was done by Raoul Tawel of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information* ***write in 55*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-18976, volume and number of this NASA Tech Briefs *issue, and the page number.*

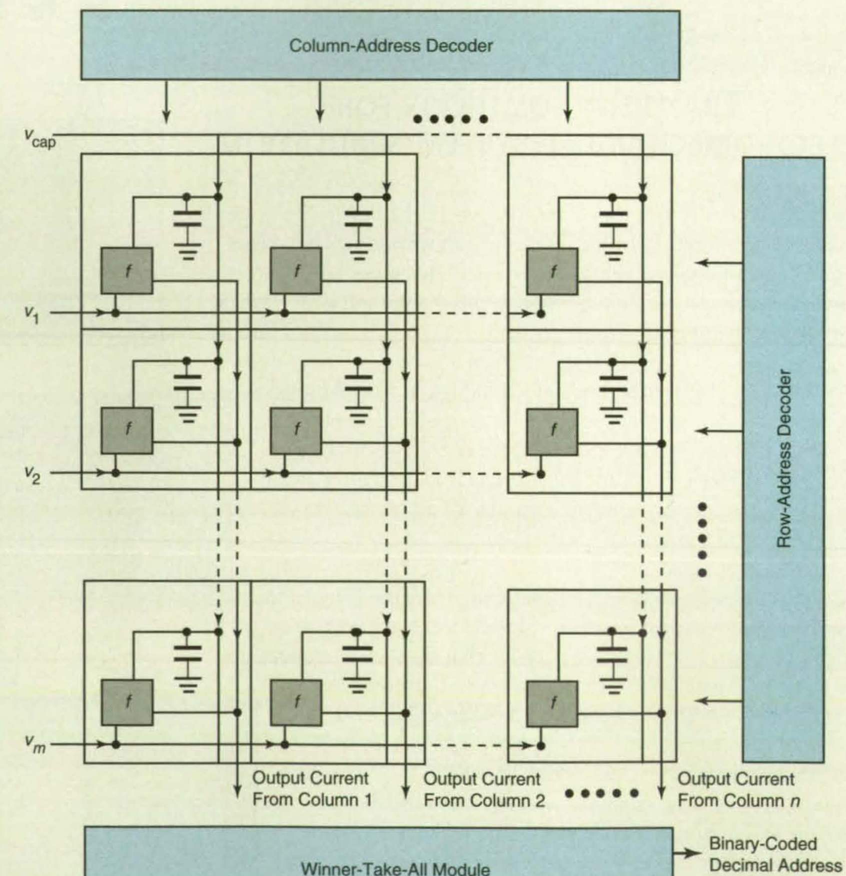


Figure 2. A **Capacitor in Each Processing Cell** stores an analog voltage that represents a component of a code vector represented by the cell.

Effect of Transition Density on Performance of a DTTL

One can estimate the minimum transition density needed to limit the symbol-error rate.

NASA's Jet Propulsion Laboratory, Pasadena, California

Theoretical calculations and the accompanying computer simulations provide the numerical basis for specification of the minimum data-transition density needed for adequate performance of a radio receiver that processes a noisy signal that contains a non-return-to-zero (NRZ) stream of data symbols (bits). By use of a digital-data-transition-tracking loop (DTTL), the receiver strives to synchronize its operation with the data symbols. The performance of the receiver in terms of its ability to keep the symbol-error rate (SER) in the output of the receiver below a specified level depends on the symbol signal-to-noise ratio (SSNR) of the incoming signal and on the degree of synchronization.

The ability of the DTTL to maintain synchronization depends partly on the SSNR and partly on the data-transition density. (The data-transition density is a statistical property of the data stream; it is the number of data transitions observed divided by the number of symbol periods of continuous observation time or, equivalently, the probability of a data transition during one symbol period. The maximum possible value of this probability is .5 if one assumes that the noise spectrum at the output of the loop phase detectors is independent of the transition density.) The degradation of performance of a first-order DTTL can be expressed by

$$\frac{\sigma_e^2}{T^2} = \frac{\xi T B_L}{8 m P_t^2 R_s \operatorname{erf}^2 \sqrt{R_s}}$$

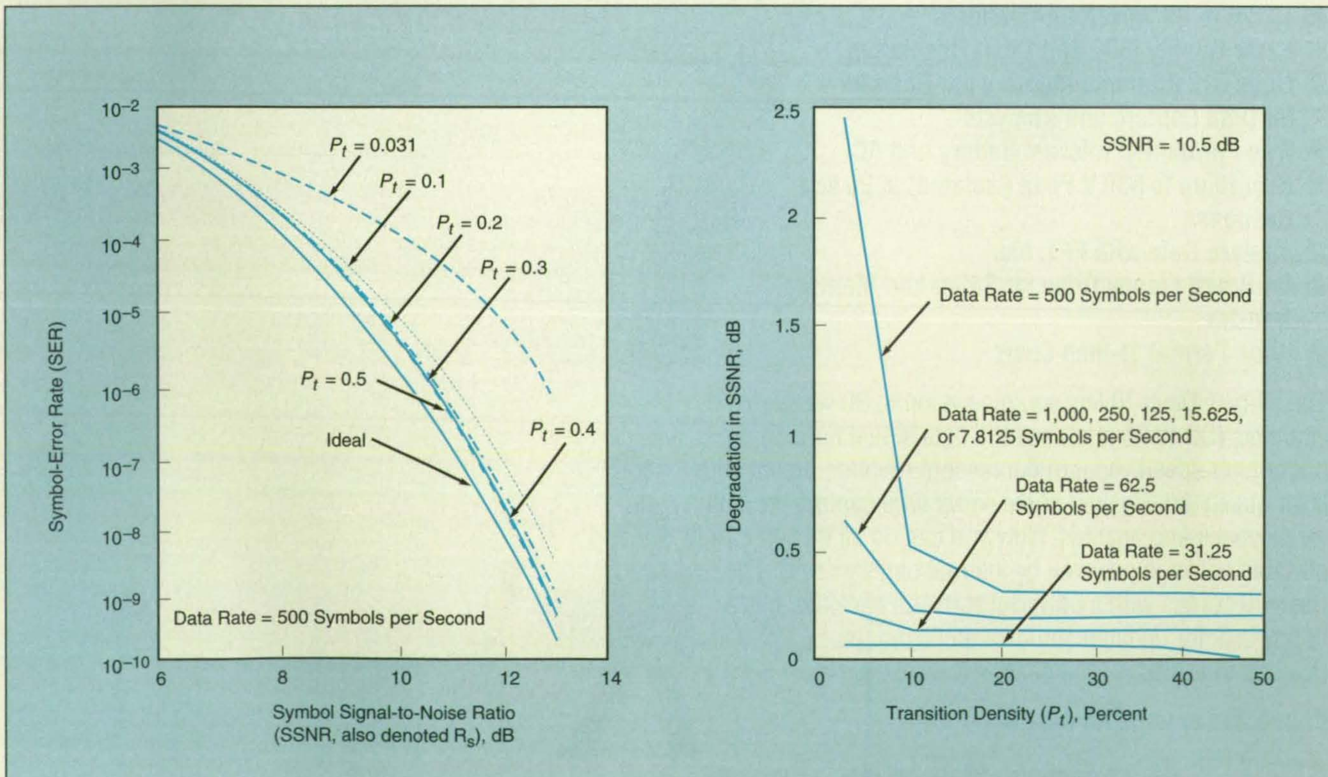
where σe is the root-mean-square timing error (symbol-synchronization jitter), T is the duration of the symbol period, ξ is the width of the window, B_L is the one-sided loop noise bandwidth, P_t is the data-transition density, m is the number of timing-error samples accumulated prior to correction of timing, R_s is the SSNR, and "erf" denotes the error function.

Of course, the performance of the receiver is degraded by timing error as well as by noise. The overall degradation of performance can be expressed as

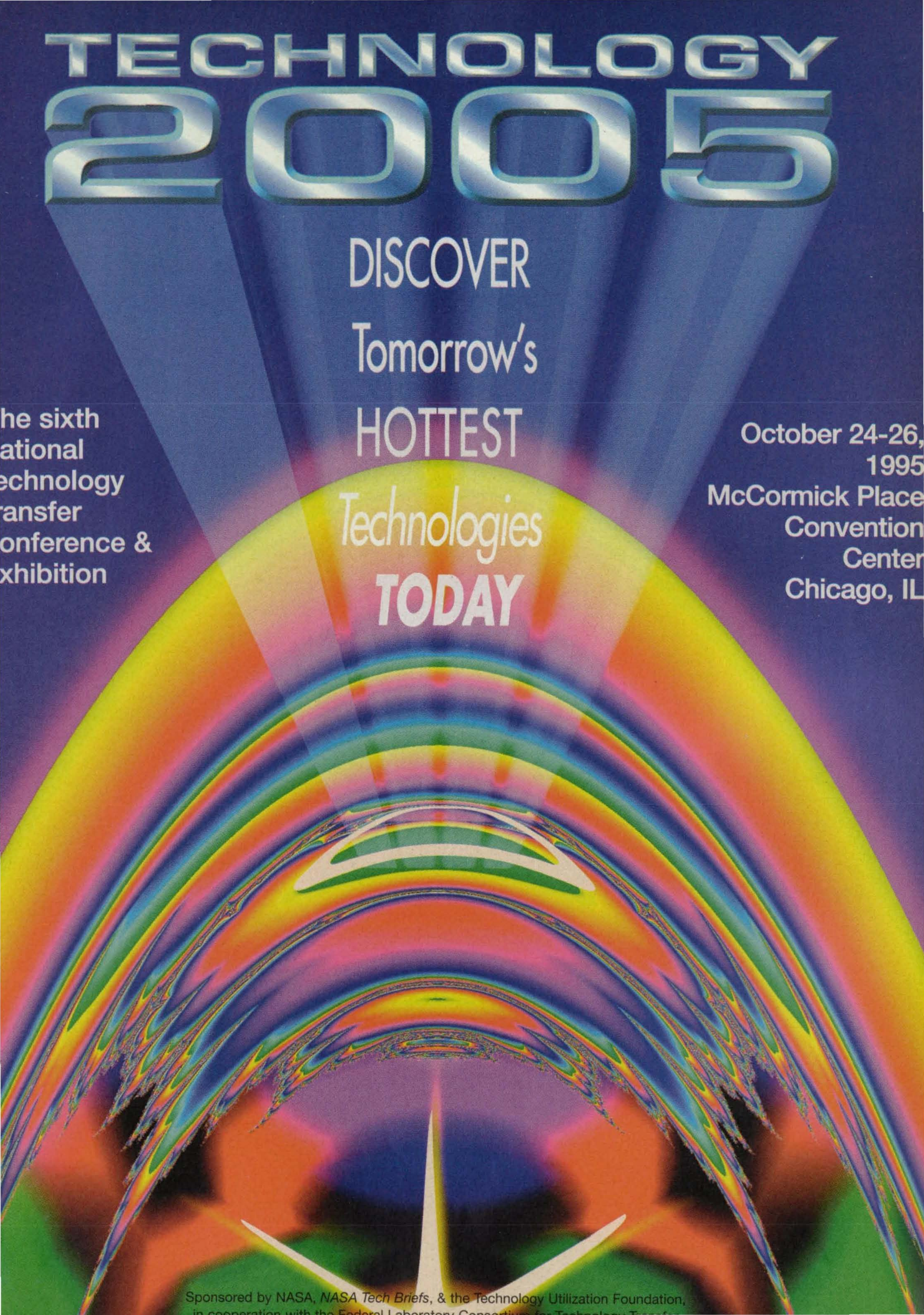
$$PE(\lambda) = \frac{1}{2} P_t \operatorname{erfc}\left[\sqrt{R_s}\,(1 - 2\,|\,\lambda\,|)\right] + \frac{1}{2}(1 - P_t)\operatorname{erfc}\left(\sqrt{R_s}\right)$$

where PE is the probability of error (or, equivalently, the SER) and λ is the timing error in units of T. The timing error computed by the first equation can be inserted in this second equation, and the resulting equation can be integrated numerically to obtain values for the degradation of performance in terms of SER for a given P_t and R_s. Alternatively, the contribution of the timing error to the degradation of performance can be expressed in terms of that decrease in SSNR that would produce the same SER in a perfectly synchronized receiver. The figure presents examples of results of such computations.

This work was done by Tien M. Nguyen and Sami M. Hinedi of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 122*** *on the TSP Request Card. NPO-18999*



The **Degradation of Performance** in terms of SER and degradation of SSNR was computed for various data rates, a window width of 1, and various values of P_t. The plot on the right can be used to select the minimum P_t needed to obtain an acceptably low degradation of SSNR at a given data rate.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> from *Enterprise Reengineering Magazine,* describing last year's event, Technology 2004

Conference-At-A-Glance

	Tuesday, October 24	Wednesday, October 25	Thursday, October 26
Registration	7:00 am - 5:00 pm	7:30 am - 5:00 pm	7:30 am - 3:00 pm
Continental Breakfast (for complete registrants, exhibitors & speakers)	8:00 am		
Welcome & Keynote Address	8:20 am - 8:45 am		
Plenary	8:45 am - 10:15 am "Transportation Tomorrow"	8:30 am - 10:00 am "Communications 2005"	8:30 am - 10:00 am "Pathsetting Environmental Programs"
Exhibition Open	10:00 am - 4:00 pm	10:00 am - 4:00 pm	10:00 am - 3:00 pm
Concurrent Workshops	10:30 am - 11:45 am • Small Business Innovation Grants: How to Apply & Win • Licensing Government Patents: A Business Primer • Industry-Government Roundtable: A Roadmap To Successful Partnerships • International Technology Transfer Forum	10:15 am - 11:45 am • Tech Transfer Success Stories • What You Need to Know to Enter into Cooperative R&D Agreements • How to Successfully Do Business with the Government Services Administration • Marketing Seminar: Finding & Owning Profitable Niche Markets	
Internet Basic Training	10:30 am - 11:30 am	10:30 am - 11:30 am	10:30 am - 11:30 am
Internet Advanced Training	2:00 pm - 3:30 pm	2:00 pm - 3:30 pm	
Concurrent Symposia	2:00 pm - 3:30 pm • Advanced Manufacturing • Environmental Technology • Materials Science • Medical Technology 3:45 pm - 5:15 pm • Display/Imaging Technologies • Microelectronics • Power & Energy • Sensors/Instrumentation	2:00 pm - 3:30 pm • Computers & Communications • Global Positioning System (GPS) Advances & Applications • Environmental Technology • Materials Science 3:45 pm - 5:15 pm • Environmental Technology • GPS Advances & Applications • Microelectronics • Robotics	10:15 am - 11:45 am • Advanced Manufacturing • Medical Technology • Power & Energy • Sensors & Instrumentation
1995 Technology Transfer Awards Dinner		7:00 pm - 9:30 pm	
Department of Energy Technology Transfer Workshop		9:00 am - 3:00 pm	

Shuttle Buses will operate on show days from the Chicago Hilton Hotel to McCormick Place every 10 minutes during peak hours and every 15-20 minutes mid-day.

TECHNOLOGY 2005 Exhibits

More than 250 of the world's premier technology resources will be showcasing hundreds of new product ideas & solutions to your engineering & business needs. They include:

Advanced Modular Power Systems
Advanced Refractory Technologies
Aeromobile Inc.
Aerospatiale
American Heuristics Corp.
American Institute for Research & Development
Ames Laboratory
Ames Research Center
Applied Material Technologies
Argonne National Laboratory
Armstrong Laboratory
Austrian Trade Commission
BF Goodrich Aerospace/Simmonds Precision
BHK Inc.
Bosma Machine & Tool Corp.
Brookhaven National Laboratory
Callaway Cars Inc.
Catalyst Advertising
Center for AeroSpace Information
Center for Research on Parallel Computation
Centro Estero Camere Commercio Piemontes
Chrysler Corp.
Corptech
COSMIC/University of Georgia
Cybernet Systems Corp.
Department of Energy Nevada Laboratories
Dryden Flight Research Center
Ecosmarte of North America
Edison Welding Institute
Electronic Displays Inc.
Eltron Research
Environmental Protection Agency
Federal Aviation Administration
Federal Highway Administration
Federal Laboratory Consortium
FLIR Systems Inc.
Force Imaging Technologies
Goddard Space Flight Center
Gulf Coast Alliance for Technology Transfer
Idaho National Engineering Laboratory
IMI-TECH Corp.
Ingenieurschule Biel
Innovative Insulation Inc.
Integrated Sensors Inc.
Inter Research Inc.
Irvine Sensors Corp.
Jet Propulsion Laboratory
Johnson Space Center
Kaiser-Hill Co. (Rocky Flats Environmental Technology Site)
Kennedy Space Center
Kinesix
Knowledge Express Data Systems
Kollmorgen Inland Motor
Lawrence Berkeley Laboratory
Langley Research Center

Transportation Tomorrow

Don't miss T2005's exciting new pavilion of cutting-edge automotive, aviation, marine, & mass transport hardware. You'll see Chrysler's Patriot hybrid electric vehicle (highlighted in Tuesday morning's plenary session); XCorp's composite one-piece molded XCAR, a computer net-designed Supercar expected to get 90 miles per gallon & reduce emissions by 80%; the Callaway SuperNatural® Corvette Le Mans, a 500+ horsepower race car featuring next-generation carbon-carbon composite engine parts; & much, much more!

Callaway SuperNatural® Corvette LeMans


The net-designed XCAR

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Los Alamos National Laboratory
Machida Inc.
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NASA Regional Technology Transfer Centers
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National Renewable Energy Laboratory
National Security Agency
National Space Society
National Technology Transfer Center
Natural Fibers Corp.
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Oak Ridge Centers for Manufacturing Technology
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Optics Technology Inc.
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PDA Inc.
Penn State University Applied Research Laboratory
Phillips Business Information Inc.
Phillips Laboratory
Powertronic Systems Inc.
Princeton University Plasma Physics Laboratory
Proto Mfg.
Ribbon Technology Corp.
Russian Space Agency
Sandia National Laboratories
Silicon Mountain Design
Society for the Advancement of Material & Process Engineering
Software Consultants Inc.
Sophia Systems & Technology
Stennis Space Center
Stress Photonics Inc.
Superior Products Intl.
Technology Access Report
Technology Transfer Business
Technology Transfer Society
Thermo Electron Tecomet
Thiokol Corp.
Tiodize Co.
Transcience Associates
TRICOR Systems
Triton Systems Inc.
U.S. Air Force Science & Technology
U.S. Army – Dept. of Army Research Labs
U.S. Army Armament Research Development & Engineering Center
U.S. Army Combat Systems Test Activity
U.S. Army TARDEC "National Automotive Center"
U.S. Army – ATC Aberdeen Test Center
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U.S. Dept. of Energy, Office of Technology Utilization
U.S. Dept. of Energy Kansas City Plant
U.S. Dept. of Energy OTD/Triodyne
U.S. Dept. of Energy Office of Clean Coal Technology
U.S. Dept. of Interior
U.S. Navy Best Manufacturing Practices/Production
U.S. Navy SBIR Program
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Virtual Worlds Inc.
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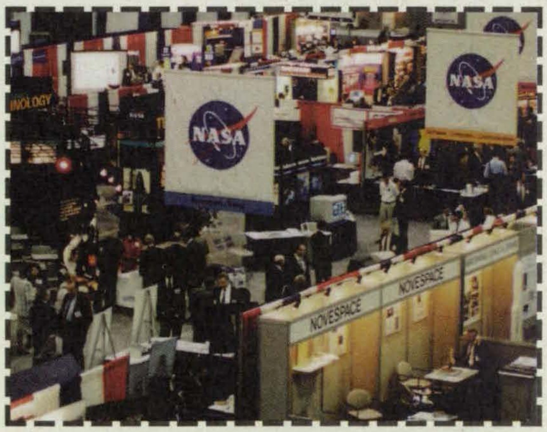
Is your organization missing from this list? Call Wayne Pierce at (212) 490-3999 to find out how you can exhibit at T2005. (Hurry! Space is limited.)

Exhibition Hours
Oct. 24: 10:00 am to 4:00 pm
Oct. 25: 10:00 am to 4:00 pm
Oct. 26: 10:00 am to 3:00 pm

NASA Rolls Out Its Best New Technologies For Transfer

Centerpiece of the T2005 exhibits hall, NASA's 5000+ square-foot pavilion presents an unparalleled opportunity to see the agency's top technologies & meet its leading researchers & tech transfer agents – all in one place, at one time. Dozens of red-hot inventions from NASA's R&D centers will be demonstrated & displayed, including:

- Active Pixel Sensor – a revolutionary imaging sensor produced at Jet Propulsion Lab (JPL) that shrinks cameras to the size of a computer chip
- Methanol Liquid Feed Fuel Cell – offering enormous potential for the energy industry, this novel solid-state energy storage device (also from JPL) is always operational–unlike batteries–& environmentally friendly
- Sensor Skin – from Kennedy Space Center, an electronic "skin" that enables robots to sense their environments & handle extremely delicate tasks
- The Simulation Virtual Machine – a real-time simulation system developed at Johnson Space Center for space shuttle & airline pilot training, now available for commercial use in entertainment, mass transit, & other industries
- Capillary Pumped Loops – from NASA Goddard, a technology for spacecraft thermal control that can be applied to heat or cool specific parts of the human body without an external power source...a boon for the sporting goods industry, firefighters, & medical device manufacturers



- Self-Nulling Probe – a low-cost, portable, nondestructive evaluation tool developed at Langley Research Center that detects cracks, corrosion, & coating thickness in metallic objects
- Ice Thickness Gauge – also from NASA Langley, a breakthrough technique for measuring & monitoring ice buildup (& in some cases initiating deicing) on aircraft, ships, & power lines

TECHNOLOGY 2005
SYMPOSIA & WORKSHOPS

Room assignments will be listed in the official show program distributed on site. Meeting rooms will be in close proximity so you can choose to attend parts of different concurrent symposia.

Tuesday, October 24

8:00 am

Continental Breakfast
(for Complete Registrants, Exhibitors, & Speakers)

8:20 am

Welcome:
Chris Coburn, Director, Great Lakes Industrial Technology Center

Keynote Address:
Daniel S. Goldin, Administrator, NASA

8:45 am (to 10:15)

Plenary: "Transportation Tomorrow"

Moderator: James Dunn, Co-Executive Director, Center for Technology Commercialization

NASA Technologies for the Transportation Industry

Charles Blankenship, Director, Technology Applications, NASA Langley Research Center

A 200 mph high-tech marvel: Chrysler's Patriot hybrid-electric-powered race car

The Patriot Hybrid Electric Car Project

Francois Castaing, Vice President of Vehicle Engineering, Chrysler Corp.

A test bed for electric vehicle technology, the 200-mph Patriot race car sports a novel flywheel energy storage system in place of a battery & burns liquid natural gas to power a 500-hp electric motor. Discover what the future holds for hybrid-powered, low-emission passenger cars.

Hydrogen-Powered Vehicles

Dr. William Summers, Hydrogen Vehicle Program Manager, Westinghouse Savannah River Co.

A promising fuel of tomorrow, hydrogen is abundant, non-polluting, versatile, & highly efficient. Learn about the Department of Energy's development of hydrogen-powered buses, & how their work will impact 21st-century roadways.

Combustion Technology–Low Emissions Program

Richard Donovan, NASA Lewis Research Center

Electric Wheels: Propulsion for the Next Millennium

David Tether, President, Town Creek Industries

Electric wheels place all the motor & braking drive components within the wheel itself, dramatically simplifying vehicle design.

Hypercars–A Glimpse of the Future

Dr. Amory Lovins, Director, Rocky Mountain Institute

Researchers are exploring ultra-light hybrid (gas/electric) cars with aerodynamic composite bodies that would deliver over 100 miles per gallon.

10:30 am (to 11:45)

Concurrent Workshops

Small Business Innovation Research (SBIR) Grants: How to Apply & Win

Vincent Schaefer, Navy SBIR Program Manager; Lee Martin, President, TRI Inc.; John Scheul, Vice President of Marketing & Sales, Virtual Computer Corp.

Highly successful in fostering commercial innovations, the SBIR program funds small U.S. businesses (with grants of up to $850,000) to meet federal R&D needs in a diverse array of fields. Federal experts will explain the program & how to propose, & two of last year's SBIR Technology of the Year award winners will share their secrets for success.

Licensing Government Patents: A Business Primer

Jay Winchester, Chief, Office of Research & Technology Applications, Army Medical Research & Materiel Command

The federal government holds rights to a myriad of patents you can obtain to develop new products & services. This workshop, sponsored by the Federal Laboratory Consortium, will cover the basics you need to know to successfully license government patents & guide you to resources that can pinpoint patents to meet your specific needs or interests.

Industry-Government Roundtable: Roadmap to Successful Partnerships

A probing discussion among industry & federal technology managers on cultural, legal, & other barriers to long-term industry-government partnering; opportunities for change; & insights on successful strategies & tech transfer models.

International Technology Transfer Forum

Presentations will include:

United States-Russia Technology Exchange

John Hnatio, Manager, New Independent States Industrial Partnering Program, U.S. Department of Energy

This DOE-Department of State program seeks to redirect the expertise of scientists & engineers in the former Soviet Union (FSU) from military to commercial applications of mutual benefit

to the U.S. & the New Independent States of the FSU. A U.S. industry coalition has been formed, & more than 175 projects are under way in materials, manufacturing, biotech, energy, waste management, & more. Find out how your firm can benefit.

2:00 pm (to 3:30)

Leading-Edge Technologies
Concurrent Symposia

Advanced Manufacturing (part 1)

Materials Joining –A Critical Enabling Technology for U.S. Manufacturers

Moderator: Dr. Neville Marzwell, Project Manager, NASA Jet Propulsion Laboratory

2:00 The Oak Ridge Materials Joining Center

Mark Richey, Program Manager, Oak Ridge Centers for Manufacturing Technology

Through the Manufacturing Technology Information Service & the National Machine Tool Partnership (both of which offer toll-free connection), this resource helps companies solve their toughest manufacturing problems. The center advises on materials & joining process selection & on welding procedures, often working with firms under Cooperative Research & Development Agreements (CRADAs).

2:30 U.S. Navy's Joining Center Teaching Factory

Richard Green, Navy Joining Center

The Teaching Factory regularly sponsors joining technology workshops, demonstrations, & application assessments, & provides engineering assistance. Find out how you can take advantage of the factory's resources to reduce your risk in implementing new technologies.

3:00 PrimeNet: An Industry-Driven Materials Joining Technology Deployment Program

Robert Kratzenberg, PrimeNet Program Manager, Edison Welding Institute

PrimeNet – managed by the Advanced Research Projects Agency, the State of Ohio, & industry partners including Allison Engine, GE Aircraft Engines, Chrysler, & Caterpillar – is an intensive assessment & technical assistance program targeted at improving materials joining in the supplier networks of key defense & commercial industry sectors.

3:15 JoinNet: A New Model for Technology Deployment

Phillip Wadsworth, JoinNet Program Manager, Edison Welding Institute

This national outreach program offers broad-based materials joining assistance & training through the growing number of manufacturing outreach centers. Mr. Wadsworth will describe the program & its successes during its first year of operation.

Environmental Technology (part 1)

Moderator: Mahendra Mathue, Group Leader, U.S. Dept. of Energy

2:00 E-SMART (Environmental Systems Management, Analysis, & Reporting neTwork)

Bruce Neilsen, Program Manager for Site Characterization, Monitoring, & Sensor R&D, Air Force Armstrong Lab

Smart highways manage traffic; smart structures measure strain; smart houses monitor lighting, heating, appliances, & security. Now a government-industry partnership promises technology for smart environmental management. The automated, sensor-based system will detect & monitor environmental contaminants including fuels, solvents, & heavy metals, as well as parameters such as pH & temperature.

2:30 Continuous Emissions Monitor for Hazardous Air Pollutant Metals

Michael Seltzer, Research Chemist, Naval Air Warfare Center Weapons Division

An innovative technique employs an inductively coupled plasma (ICP) spectrometer to detect – in real time – airborne pollutant metals such as lead, cadmium, & mercury in the effluent of incinerators, industrial combustors, & other sources.

3:00 Synthetic Aperture Radar (SAR) – Dual-Use Applications

J. Verdi, P-3 SAR Project Manager, Naval Air Warfare Center Aircraft Division

SAR is a leading-edge remote sensing tool used by the military in ocean imaging, terrain assessment, & surveillance. Mr. Verdi will spotlight emerging commercial applications including wetlands monitoring, oil spill mapping, & environmental disaster imaging.

Materials Science (part 1)

Moderator: William Waters, Materials Engineer, NASA Lewis Research Center

2:00 LaRC-SI: A Unique High-Performance Thermoplastic

Robert Bryant, Research Engineer, NASA Langley Research Center

This award-winning material, which can be used to bond a variety of metals, ceramics, & polyimide films, offers the unique combination of extreme toughness & fracture resistance, excellent electrical properties, & solubility.

2:30 Application of Metal/Insulator Composites as Moldable Surge Arrest Materials

Hamid Javadi, Jet Propulsion Laboratory

Composites of metal particles embedded in a background of insulating material have been used to manufacture surge arrest materials (which switch to "short" under high voltages)

– albeit with an arduous development phase. An advantageous switching to "open" in a silver epoxy preform promises to benefit airplanes, cars, measurement instruments, & home electronics.

3:00 SUPER THERM Ceramic Coating Insulation

JE Pritchett, President, Superior Products Intl.

A water-borne coating spun off from NASA research has proven an outstanding insulator in harsh weathering conditions. Mr. Pritchett will outline how he worked with NASA to commercialize this technology & describe successful applications worldwide.

Medical Technology (part 1)

Moderator: Paul Bennett, Manager, Technical Marketing, Virtual Prototypes Inc.

2:00 Ultrabright X-ray Light Sources for Biological Microimaging

Charles Rhodes, Laboratory for Atomic, Molecular, & Radiation Physics, University of Illinois at Chicago

A revolutionary x-ray imaging system could shed important light on how the body works on the cellular level. The laser-based system can capture 3D pictures of the molecular anatomy of living cells & tissues.

2:30 CCD-Based Mosaic Digital Mammography

James McAdoo, Electronics Engineer, NASA Langley Research Center

An all-digital mammography imager achieves unprecedented spatial resolution, providing full-breast coverage. Mr. McAdoo will explain the technology's advantages & its (significant) market potential.

3:00 High-Precision Calibration of Body Composition Measurements

Dr. Ruimei Ma, Associate Scientist, Brookhaven National Laboratory

Brookhaven's in vivo neutron activation (IVNA) facilities offer a rapid, reliable, & relatively inexpensive way to gauge body composition for research on aging, malnutrition, & diseases such as AIDS & osteoporosis. With absolute precision, they can calibrate instruments for clinical body composition studies using IVNA analysis.

3:45 pm (to 5:15)

Leading-Edge Technologies
Concurrent Symposia

Display/Imaging Technologies

Moderator: Robert Doornick, President & CEO, International Robotics Inc.

3:45 Laser-Based 3D Volumetric Display System

Parviz Soltan, Scientist, Naval Command, Control, & Ocean Surveillance Center

A Navy-developed 3D display shows exciting promise for dual-use applications in air traffic control, medical imaging, & television. (A 3D TV would allow the home viewer to watch from all sides, without the special glasses that limit 3D motion picture viewing.) It employs lasers focused on the surface of a spinning double helix to generate points of light in space, thereby forming 3D images of the data presented.

4:15 Augmented Virtual Vision Head-Mounted Displays

Michael Ohanian, Marketing Manager, Virtual Vision Inc.

Boeing, Carnegie Mellon, & Virtual Vision have teamed to produce lightweight head-mounted displays for the industrial maintenance market. They project video information such as manuals & mechanical drawings to the wearer, whose hands remain free & surroundings stay in view at all times.

4:45 Diver Heads-Up Display

Dennis Gallagher, Naval Coastal Systems Station

A compact, mask-worn display module delivers color NTC video, text, & graphics to divers at depths approaching 100FSW. Underwater cameras & sonar, navigation & life support systems, & undersea video classrooms are just some of the areas with immediate commercial potential.

Microelectronics (part 1)

Moderator: Yahong Jin, Senior Optical Engineer, Standard Intl. Inc.

3:45 A Novel Method for Fabricating Flexible Printed Circuits

Nancy Kruse, NASA Langley Research Center

A self-bonding soluble polyimide developed at NASA Langley is the key to producing completely adhesive-free flexible circuits. Benefits: reduced material & processing costs & lighter end-weight circuits with increased flexibility.

4:15 Aluminum Nitride in Microelectronic Packaging

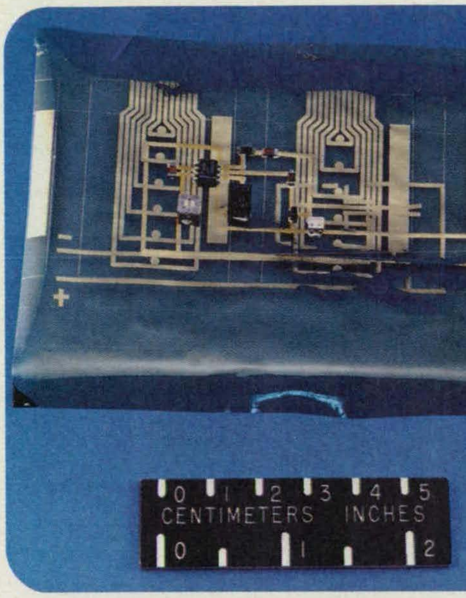
Stephen Elliott, Carborundum Co.

The evolving "miracle material" called aluminum nitride (AlN) can dramatically improve chip & component performance through improved thermal management, & enable the U.S. to leapfrog competitors in the global microelectronics market. Carborundum is working with ARPA and the Air Force to develop low-cost AlN packaging for applications ranging from automobiles to wireless telephones to military equipment.

4:45 Vertical Thin-Film-Edge Field Emitter Arrays Promise Low-Cost, High-Performance, Energy-Efficient Flat-Panel Displays

David Hsu, Research Chemist, & Henry Gray, Research Physicist, Naval Research Laboratory

The exploding multi-billion-dollar flat-panel display industry is dominated by active matrix liquid crystal displays, which are expensive, energy-inefficient, very temperature-sensitive, & exhibit poor visual characteristics. The presenters will describe how new field emitter displays (FEDs), fabricated by chemical beam deposition, overcome these limitations to deliver superior performance.



Fabricating Flexible Printed Circuits

Power & Energy (part 1)

Moderator: Roy Ruth, Video Monitors Inc.

3:45 Novel, Renewable Liquid Fuel (Algahol) Production Plant

Tammy Kay Hayward, National Renewable Energy Laboratory

Algahol is an environmentally-friendly energy source blending two well-known renewable fuels: ethanol & bio-diesel. An algahol production facility as described in this presentation would enable small, remote cities (including space stations) to easily convert agricultural wastes, water, and sunlight into their own fuel supply.

4:15 Thermophotovoltaic Energy Conversion

David Wilt, NASA Lewis Research Center

NASA has developed a thermophotovoltaic power system that efficiently converts heat into electrical energy for automotive, utility, & other power-generating applications. TPV could propel an electric vehicle & is ideal for cogeneration applications such as self-powered natural gas furnaces.

4:45 H.E.A.T. Machines

George Wiseman, President, Eagle Research Inc.

An innovative, low-cost system can gather ambient heat from ground, water, air, & solar sources to drive electrical generators. This zero-emission technology is based on the Wiseman Cycle, which, according to its developer, approaches a perfect "Carnot" efficiency rating.

Sensors/Instrumentation (part 1)

Moderator: Mohan Aggarwai, Professor of Physics, Alabama A&M University

3:45 The Revolutionary Active Pixel Sensor

Eric Fossum, Jet Propulsion Laboratory

A new imaging sensor – virtually a camera on a chip – promises to dramatically reduce the size, cost, & complexity of imaging systems. Featuring on-chip timing & control electronics, it represents a leap beyond current state-of-the-art CCD devices.

4:15 Optically-Transparent, Fiber-Compatible Glass for Remote Radiation Sensing

Alan Huston & Brian Justus, Research Chemists, Naval Research Laboratory

The Navy has created an all-optical radiation sensor for medical radiotherapy, nuclear waste monitoring, & manufacturing process control. Its advantages over traditional thermoluminescence dosimetry: better sensitivity, larger linear dynamic range, lower cost, & the capability for remote, near-real-time monitoring.

4:45 Robust Quantitative Measurement of Transparent or Reflective Objects

Carolyn Mercer, Optical Engineer, NASA Lewis Research Center

A new instrument, the liquid crystal point diffraction interferometer, accurately measures optical wavefronts. It offers a useful tool for automated data acquisition & reduction, with very high data density, for applications requiring a compact, robust, inexpensive interferometer.

Wednesday, October 25

8:30 am (to 10:00)

Plenary: "Communications 2005: The Future is Digital"

See how the latest developments in digital technology will impact home entertainment, health care, engineering design, and business communications. Highlights will include a live demonstration of a new telemedicine system introduced by NASA, the University of Texas Health Sciences Center (UTHSC-SA) in San Antonio, Sprint, and VTEL to help the medically underserved area of South Texas. Dr. James Legler of UTHSC-SA will display the system's two-way audio/video linkages, remotely conduct a patient examination, and demonstrate how this trailblazing technology will impact the cost and quality of medical care.

10:15 am (to 11:45)

Concurrent Workshops

Tech Transfer Success Stories: Profit from Experience

- The Clean Coal Technology Demonstration Program
  Dr. C. Lowell Miller, Associate Deputy Secretary for Clean Coal, U.S. Dept. of Energy
- A New Way of Doing Business: NASA Ames-Rockwell Partnership to Develop Reusable Launch Vehicle Thermal Protection Systems
  Carol Carroll & Michael Green, Ames Research Center; Mary Fleming & Peter Hogenson, Rockwell Intl.
- The Gulf Coast Alliance for Technology Transfer: An Innovative Alliance of Academic & Defense Laboratories
  William Huffman, GCATT, & Cris Johnsrud, STAC
- SBIR Successes: Advanced Ceramics Research & Convolve Inc.
  Anthony Mulligan, President, Advanced Ceramics Research; Neil Singer, President, Convolve Inc.

What You Need to Know to Enter into Cooperative Research & Development Agreements (CRADAs)

Jay Winchester, Chief, Office of Research & Technology Applications, Army Medical Research & Materiel Command

Federal law now allows companies & government labs to pool their resources & share risks in developing new technologies, usually with the company maintaining intellectual property rights to any resulting discoveries. Thousands of these agreements already are in place and more are being inked every day. Find out where CRADA opportunities lie & how to take advantage of them.

How to Successfully Do Business with the Government Services Administration

Miranda Jackson, Acting Associate Administrator, Office of Enterprise Development, GSA

Gain marketing tips & strategies for targeting the federal government as a potential customer–specifically the GSA, the principal federal buyer (over $9 billion annually) of office equipment, hardware, telecommunications equipment, construction & maintenance services, & more.

High-Tech Marketing Seminar: Finding & Owning Profitable Niche Markets

William Dorman, Founder, Dorman Associates Inc.

Whether your product is recently patented, emerging, or mature, this session will give you techniques for finding potential markets, pinpointing which segments offer the best opportunities, & "owning" a segment once you enter it. The instructor brings some 20 years experience in marketing & management engineering consulting with over 100 international clients.

2:00 pm (to 3:30)

Leading-Edge Technologies
Concurrent Symposia

Computers & Communications

Moderator: Bea Shahin, ORTA Program Coordinator, USACERL

2:00 Distributed Application Monitor Tool (DAMT)/Visualization Environment (DAVE)

Benjamin Keith, Project Manager, NASA Goddard Space Flight Center

DAMT is a UNIX-based tool that automatically locates & monitors communication processes & circuits between processes, reporting traffic back to multiple users through an application program interface. DAVE, a graphical user interface, provides distributed application developers an intuitive way to specify & monitor distributed applications.

2:30 State Recognition for Noisy Dynamic Systems

Dr. Henry Pfister, President, Standard Object Systems

Novel algorithms form the basis for a visually programmable software system that solves complex real-time computer recognition problems for dynamic systems. It's been applied successfully to the development of a continuous speech recognition program & to 3D image processing, with other applications on the horizon in chemical processing, flexible manufacturing, & environmental monitoring.

3:00 Emerging CASE Tool from RMA Technology

Cynthia Mavros, Software Engineer/Principle, Introspect Technologies Inc.

An affordable, real-time software development tool offers utility in transportation, biomedicine, manufacturing, & other commercial arenas. It's based on Rate Monotonic Analysis, a method for predicting & analyzing the timing behavior of real-time systems.

Global Positioning System (GPS) Advances & Applications (part 1)

(Sponsored by NASA's Jet Propulsion Laboratory)

Moderator: Robert Price, California Design

2:00 The TurboRogue Family of GPS Space & Ground Receivers for High-Precision Navigation, Surveying, & Earth Science

L. Young, T. Meehan, J. Srinivasan, J. Thomas, & D. Spitzmasser, Jet Propulsion Lab

2:30 GIPSY Software for High-Precision GPS Data Analysis & System Design

S. Wu, W. Bertigar, S. Lichten, R. Muellerschoen, Y. Barever, & M. Heflin, Jet Propulsion Lab

3:00 The International GPS Network for Charting the Evolving Global Reference Frame

J. Zumberge, M. Heflin, U. Lindqwister, R. Neilan, & M. Watkins, Jet Propulsion Lab

Environmental Technology (part 2)

Moderator: Gerald Draub, Principal Scientist, RUST Geoptech

2:00 Precision Cleaning & Processing System

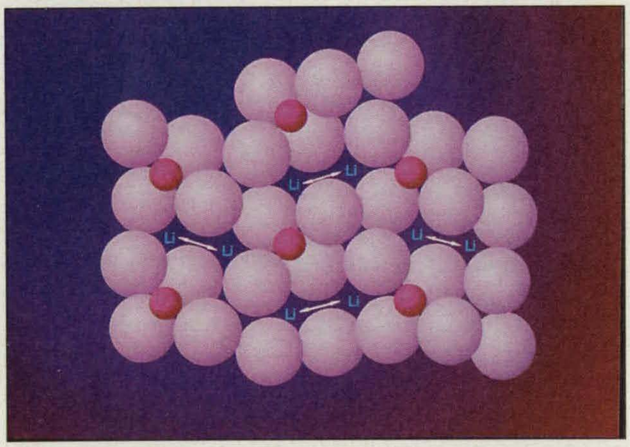
Rajiv Kohli, Program Manager, Battelle Memorial Institute

Commercial industries need better ways to recover & recycle valuable materials such as electronic circuit boards & gold plating from small, complicated parts. Battelle has developed a nonsolvent cleaning/processing system that recovers these materials, reduces the waste generated, and removes any radioactive or other hazardous contamination. The system, which sprays abrasive powder through a miniature nozzle, also can be used in coating removal, drilling, cutting, & etching.

2:30 Chloride-Free Processing Technology for Recycling Aluminum Scrap

W.D. Riley, U.S. Bureau of Mines Albany Research Center

The Bureau of Mines is applying engineered scavenger compounds (ESCs) to recover materials from aluminum scrap. Advantages: The ESCs are designed to have a high degree of selectivity for a desired ionic species; the recovered material requires little or no additional reprocessing prior to reuse; & the process does not generate fugitive emissions or hard-to-dispose-of slags.



3:00 Micro-organisms Cost-Effectively & Safely Treat Waste

Dr. Fred Gilliard, President, Bearehaven Reclamation

Two pioneers of bioremediation technology – Westinghouse Savannah River Company & Bearehaven Reclamation – have teamed to investigate ways to better deploy microbes that break down contaminants in disposal sites, industrial locations, & waterways...a natural solution for reducing pollution & landfill volume.

Materials Science (part 2)

Moderator: Howard Novak, Staff Scientist, USBI Corp.

2:00 High-Quality Flexible Superconducting Films

Paul Arendt, Los Alamos National Laboratory

Los Alamos researchers have hit a new milestone in superconductivity: a flexible ceramic-metal tape that superconducts electricity at -320 °F, allowing the use of inexpensive liquid nitrogen as a coolant. Practical payoffs: improved electric motors, medical imagers, & magnetically-levitated trains.

2:30 Compliant Substrates for Semiconductor Optoelectronic Devices

M. Stumborg, F. Santiago, & T.K. Chu, Naval Surface Warfare Center

Using a molecular beam epitaxy process, the Navy has successfully grown a variety of technologically important semiconductors on GaAs and Si wafers. Their work will allow manufacturers to produce optoelectronic devices of truly monolithic architecture.

3:00 Enabling Technology for Low-Level Hydrogen Detection

Daryush Ila, Director, Center for Irradiation of Materials, Alabama A&M University

A new invention enables manufacturers to detect & measure extremely low levels of hydrogen in materials, paving the way for advanced techniques to prevent hydrogen embrittlement & electrical/optical device failure.

3:45 pm (to 5:15)

Leading-Edge Technologies
Concurrent Symposia

Environmental Technology (part 3)

Moderator: James Olsta, Vice President, Environmental Planning Group

3:45 Pulse Tube Refrigeration

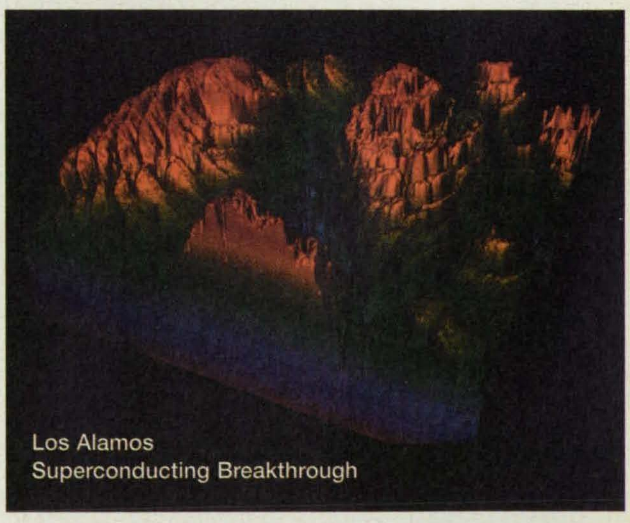
William Dean, President, Dean Applied Technology Co.; Douglas Westra, Aerospace Engineer, NASA Marshall Space Flight Center

The presenter has developed a technology that uses no CFCs, only inert helium, to cool spacecraft systems. Commercial potential: industrial & home refrigerators/freezers, medical lab freezers, & cooling of computers & consumer electronics.

4:15 Commercial Applications for Ozone Generated by Electrolysis

Duncan Hitchens, Lynntech Inc.

A novel electrochemical process generates ozone to treat & purify water. Designed for space life support systems, the technology offers a host of commercial uses – from treating hazardous wastewater to disinfecting high-purity water in the semiconductor industry.



Los Alamos
Superconducting Breakthrough

4:45 Zeoponic Media: An Artificial Soil for Plant Growth on Earth & in Space

D.W. Ming, D.J. Barta, & D.L. Henninger, NASA Johnson Space Center

A highly-fertile, synthetic soil developed for space use also has many down-to-Earth applications in the horticultural industry.

Global Positioning System (GPS) Advances & Applications (part 2)

3:45 The Dense GPS Array in Southern California: A New Tool for Seismic Hazard Assessment

A. Donnellan, K. Hurst, J. Scheid, M. Watkins, & F. Webb, NASA Jet Propulsion Lab

4:15 Centimeter Orbit Determination with GPS for Precise Earth Observation

W. Bertiger, S. Wu, R. Meullerschoen, T. Yunck, & J. Guinn, Jet Propulsion Lab

4:45 Satellite Constellations for Atmospheric Sounding with GPS: A Revolution in Climatology, Weather Modeling, & Ionospheric Research

T. Yunck, D. McCleese, W. Melbourne, C. Thornton, G. Hajj, U. Lindqwister, & A. Mannucci, Jet Propulsion Lab

Microelectronics (part 2)

3:45 Diagnostician™-on-a-Chip

Dr. Michael Granieri, President, Giordano Automation

A knowledge base & inference engine contained within a single-chip microcontroller automates power system diagnostics. It can generate fault diagnoses in real time & effect system reconfiguration & recovery.

4:15 Low-Noise, Two-Stage Series Array SQUID Amplifiers

Dr. Peter Shirron, NASA Goddard Space Flight Center

Superconducting Quantum Interference Devices (SQUIDs) have gained widespread use in the last decade due to their superior ability to detect extremely small changes in magnetic flux. Goddard has introduced a two-stage SQUID device offering improved sensitivity in a smaller, less complex package. Applications: medical diagnostics, nondestructive evaluation, defense electronics, & much more.

4:45 Multi-Sensory Optoelectronic Feature Extraction Neural Associative Retriever (MOFENAR)

Jahong Jin, Standard International Inc.; Hua-Kuang & Neville Marzwell, NASA Jet Propulsion Laboratory

An innovative feature extraction system achieves storage & addressing capacity of 2000 parallel optical channels – an order of magnitude higher than other techniques. Potential uses range from automated smart robotics vision to fingerprint identification in security systems.

Robotics

Moderator: Dr. Gerald Roston, Research Engineer, Cybernet Systems Corp.

3:45 Visual Inspection Planar Serpentine Manipulator (VIPER)

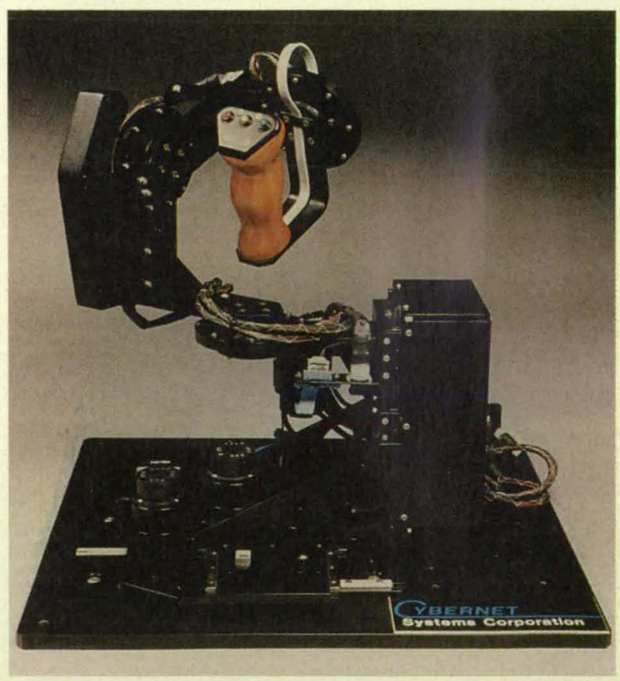
Dr. Neville Marzwell, NASA Jet Propulsion Laboratory & Adam Slifko, Redzone Robotics Inc.

The VIPER, a snake-like, kinematically-controlled robot with a small CCD camera for eyes, is ideal for inspection tasks in dangerous or highly restricted work sites. Its utility ranges from aircraft engine inspection to explosives handling to in-orbit servicing of spacecraft.

4:15 Whole-Arm, Dexterous Master Manipulator

Vikas Sinha, Michael Whalen, & Thomas Peurach, Research Engineers, Cybernet Systems Corp.

An integrated force-reflecting arm, hand, & finger system generates force feedback in teleoperated or virtual environments, making it an ideal controller for a teleoperated robot arm.



4:45 Omnidirectional Telerobotic Transporter

Hillery McGowen, Project Engineer, Naval Surface Warfare Center; Colonel Bruce Altschuler, U.S. Air Force/Army Dental Sciences Liaison, Walter Reed Army Institute of Research

The Navy is developing an intelligent omnidirectional vehicle to serve as a surgical assistant during battle or disaster relief. Through R&D partnerships with industry, this technology is being adapted for a wide spectrum of non-defense uses, from hazardous waste cleanup to aviation equipment handling.

7:00 pm (to 9:30)

1995 Technology Transfer Awards Dinner

Chicago Hilton Hotel & Towers

Invited guest speaker: Eugene Kranz, flight director of the Apollo 13 mission.

An outstanding networking opportunity, the awards dinner will bring together over 500 industry & government leaders to honor companies & individuals who have successfully translated research innovations into products/services that benefit the national economy & everyday life. One dinner ticket is included with your complete registration.

Thursday, October 26

8:30 am (to 10:00)

Plenary: "Pathsetting Environmental Programs"

The U.S. National Environmental Technology Strategy

Dr. Thomas Houlihan, U.S. Interagency Environmental Technologies Office

Dr. Houlihan will present the key elements of the Bridge to a Sustainable Future, the national environmental technology strategy recently released by Vice President Gore. It considers a new challenge for the nation – one of sustainable development – and puts forward initiatives to ensure that American environmental technology is dominant in the global market.

NASA's Mission to Planet Earth

Granville Paules, Director, Technology Innovation and Systems Integration Office, NASA

This ambitious, exciting program will employ a flotilla of remote sensing satellites to study the Earth's oceans, land masses, & atmosphere, in a long-term effort to map how the planet's systems interact & change. The results should greatly enhance our understanding of environmental problems and aid in environmental planning.

Pioneering Applications of Remote Sensing

Kass Green, President & Co-Founder, Pacific Meridian Resources

Ms. Green, a nationally recognized forestry & remote sensing expert, will describe how GIS & remote sensing technologies are impacting natural resource management & policy analysis.

EPA-Industry Partnerships: Successes & Lessons Learned

Larry Fradkin, Federal Technology Transfer Act Coordinator, & Jane Ice, Technology Transfer Specialist, U.S. Environmental Protection Agency

The EPA's CRADA program with industry has generated an array of important new environmental technologies & products, such as toxic waste cleanup techniques, instrumentation for low-level automobile emissions, & a recently patented chemical destruction process for PCBs. How will this experience shape future partnership opportunites? Find out from the EPA's tech transfer experts.

10:15 am (to 11:45)

Leading-Edge Technologies
Concurrent Symposia

Advanced Manufacturing (part 2)

Moderator: Dr. Darvin Bloemaker, Western Illinois University


Nanotechnology

10:15 Nanotechnology – The Next Industrial Revolution?

Bobby Sumpter & Robert Tuzun, Oak Ridge National Laboratory

Scientists in ORNL's Chemical & Analytical Sciences Division are focusing on building machines at the atomic level. These microscopic devices may one day travel the bloodstream to fight diseases or attack contaminants in soil or water. The researchers will detail how they are using advanced computer modeling techniques to design & simulate atomic-scale gears & bearings.

10:45 Fabrication Techniques for Manufacturing Advanced Composite Hardware

Jill Griffin, NASA Goddard Space Flight Center

This presentation will reveal a host of labor- and time-saving composite fabrication techniques developed at Goddard to support flight projects...and now available to commercial manufacturers to help bolster productivity & profits.

11:15 Thick-Film Metallization Process for Soldering & Brazing to Non-Metals

James Intrater, Director of Technology, Oryx Technology Corp.

An ingenious process called Intragene™ bonds non-metals such as graphite & carbon-carbon composites to other materials. Braze joints formed between TZM alloy and graphite have withstood temperatures exceeding 1000 °C.

Medical Technology (part 2)

Moderator: Donald Friedman, Technology Manager, Futron Corp., NASA Goddard Space Flight Center

10:15 Compact Fiber-Optic Eye Diagnostic System

Drs. Rafat Ansari & Kwang Suh, NASA Lewis Research Center

A fiber-optic probe developed for microgravity science experiments has been reapplied to the early detection of cataracts. Flexible & easy to use, the probe has no moving parts & does not require optical alignment. It contains a miniature microscope for imaging of the eye.

10:45 Dried Blood Chemistry Method

Dr. Peggy Whitson, NASA Johnson Space Center, & Dr. Vaughan Clift, Lockheed Martin

Originally developed to preserve blood samples during space flight and now available for commercial licensing, this inexpensive & highly accurate technique can be used to screen for blood-borne diseases, drugs, cholesterol, or bacterial infections. The estimated market: $2 billion.

11:15 Left Ventricular Assist Device (LVAD) for the Human Heart

Michael Barrett, NASA Johnson Space Center

NASA is seeking a commercial partner to further develop a small implantable device that deploys an axial flow pump to help weak hearts pump blood. In the U.S. alone, the estimated need for an LVAD is 50,000 - 60,000 patients annually.

Power & Energy (part 2)

Moderator: Ann Rydalch, Mission Development, Lockheed Martin Idaho Technologies

10:15 Long-Life, High-Reliability, Environmentally-Sound Electric Generators

Jeff Lubeck, Stirling Technology Co.

Breakthroughs in low-cost linear motor/alternator & high-performance heat exchanger technologies are being applied to commercial electric power generators & low-temperature refrigerators.

10:45 Hydraulic & Pneumatic Technology to Revolutionize Internal Combustion Engine Lubrication Systems

Dr. John Allen Marshall, East Carolina University

Dr. Marshall will illustrate a simple, automated device proven to reduce engine wear by up to 80%. The lubrication-enhancing device can be added to existing engines or designed into new productions.

11:15 Applying Balanced Pistons Valve Technology

Robert Jaeger, BP Valve Technology

A highly efficient valve design dramatically shrinks size, weight, & power requirements of fluid controls. The invention balances the pressure in pipes like a vehicle's wheels balance a load.

Sensors/Instrumentation (part 2)

Moderator: Anthony Sammells, President, Eltron Research Inc.

10:15 Capaciflector-Based Technology

John Vranish, NASA Goddard Space Flight Center

Goddard has produced capacitive proximity sensors superior in range & sensitivity by an order of magnitude, with thermal drift problems virtually eliminated. Applications range from smart guided robotic tools to automobile air bags.

10:45 PC Windows-Based Bolt Analyzer

Peter Rossoni, NASA Goddard Space Flight Center

A portable, user-friendly instrument supplies instant information about bolt parameters. The Bolt Analyzer computes and answers the one unknown in all bolt problems: the coefficient of friction.

11:15 Eddy Current Residual Stress Measuring System

E. James Chern, NASA Goddard Space Flight Center

Mr. Chern will describe a patented technique for quickly gauging the residual stress of aging aircraft, bridges, & other structures.

9:00 am (to 3:00 pm)

Concurrent Meeting

Department of Energy (DOE) Technology Transfer Workshop

Sponsored by the DOE Chicago Operations Office

Internet Training Sessions

(held in the exhibits hall)

Internet 101

Oct. 24-26, 10:30 - 11:30 am

Net "nuts & bolts"...How to get connected & choose the best service providers...Basic search tools & techniques... Understanding the World Wide Web

Advanced Internet

Oct. 24-25, 2:00 - 3:30 pm

Hot sites for engineers & scientists...Important tips for building your own web page...What you must know about security & encryption

Preregister & Save

	by 10/13	On-site
Complete Registration	**$275**	**$350**

(includes Technology 2005 symposia, workshops, Internet training & exhibits; opening session breakfast; awards dinner; & a set of official proceedings)

One-Day Registration	**$95**	**$125**
Awards Dinner Only	**$55**	**$65**
Internet Training	**No Charge**	**$25**
Exhibits Only		**No Charge**

Preregistrants will receive written confirmations via mail along with their name badges & inquiry cards. Badge holders, programs, and dinner tickets must be picked up in person at the McCormick Place convention center beginning at 12:00 pm on Monday, October 23. For group discounts call 1-800-944-NASA.

Air Travel Discounts

Exhibitors and attendees who book their tickets via United Airlines' toll-free #(800) 521-4041 will receive a 10% discount off unrestricted BUA fares or a 5% discount off any United or United Express published fare. When reserving your tickets you must refer to meeting ID#589NZ.

Special Hotel Discounts

The following special rates have been negotiated for Technology 2005 exhibitors & attendees:

Chicago Hilton & Towers - Headquarters Hotel

Standard	$105 sgl/$125 dbl
Superior	$125 sgl/$145 dbl
Deluxe	$145 sgl/$165 dbl
Towers	$170 sgl/$190 dbl
Gov't Rate	$104 sgl/dbl (inclusive)

All the above rates are subject to 14.9% tax with exception of the government rate which is inclusive.

Rates are not guaranteed after Oct. 1, 1995.

To make reservations call (312) 922-4400 or toll free 1-800-HILTONS and identify yourself as a Technology 2005 attendee. All reservations require a first night advance deposit.

Reserve early to confirm your preferred rate category!

Benefits of staying at the Headquarters Hotel

Shuttle buses will only operate from the Chicago Hilton Hotel & Towers to McCormick Place.

The awards dinner will be held at the Chicago Hilton Hotel & Towers.

NTB9

Preregistration Form

USE A SEPARATE FORM OR PHOTOCOPY FOR EACH REGISTRANT. BE SURE TO ANSWER ALL QUESTIONS BELOW.
DO NOT USE THIS FORM IF YOU ARE AN EXHIBITOR OR SPEAKER.

Name ____________________
Title ____________________
Company ____________________
Address ____________________ place label here
City/St/Zip ____________________
Phone No. ____________________
Fax No. ____________________
E-Mail Address ____________________

Please register me for the following: (check all that apply)

	by 10/13	after 10/13
A ❒ Complete Registration (includes 1 ticket to Awards Dinner)	$275	$350
B ❒ One-Day Symposia/Exhibits	$95	$125
check day: ❒10/24 ❒10/25 ❒10/26		
C ❒ Awards Dinner: ________ tickets @	$55	$65
D ❒ Exhibits only	Free	Free
E ❒ Internet Training	Free	$25

TOTAL: $ ________

❒ Check/MO enclosed (payable to Technology Utilization Foundation)

❒ Charge my: ❒ Mastercard ❒ VISA ❒ Am Ex

Card No. ____________________ Exp. Date ____

Cardholder Name ____________________

Signature ____________________

Registrations & Awards Dinner reservations are transferrable. Cancellations must be received in writing by October 13 for a full refund. Refunds will not be granted for "no shows."

1 **Which of the following best describes your industry or service? (check one)**

1 ❒ Electronics
2 ❒ Computers
3 ❒ Communications
4 ❒ Aerospace
5 ❒ Defense
6 ❒ Government
7 ❒ Materials/Chemicals
8 ❒ Industrial Equipment
9 ❒ Manufacturing
10 ❒ Power/Energy
11 ❒ Biomedicine
12 ❒ Transportation/Automotive
13 ❒ Research Lab
14 ❒ University
15 ❒ Other (specify) ________

2 **Which of these products do you recommend, specify, or authorize the purchase of? (check all that apply)**

16 ❒ Electronic Components & Systems
17 ❒ Software
18 ❒ Computers/Peripherals
19 ❒ CAD/CAE/CAM/CASE
20 ❒ Lasers/Optics
21 ❒ Materials
22 ❒ Mechanical Components
23 ❒ Positioning Equip./Motion Control
24 ❒ Test/Measurement Instruments
25 ❒ Sensors/Transducers
26 ❒ Data Acquisition
27 ❒ Video/Imaging Equipment
28 ❒ Industrial Controls/Systems
29 ❒ Communications Equipment
30 ❒ Laboratory Equipment

3 **Your role in purchasing is:**

31 ❒ Decision maker 32 ❒ Specify 33 ❒ Recommend

4 **Your principal job function is: (check one)**

34 ❒ General & Corporate Management
35 ❒ Design & Development Engineering
36 ❒ Engineering Services - Tests/Quality
37❒ Basic Research
38 ❒ Manufacturing/Production
39 ❒ Purchasing/Procurement
40 ❒ Other (specify) ________

If you require assistance to fully participate call Tricia Palumbo at 1-800-944-NASA.

Return with payment to: c/o Technology 2005, PO Box 805, Islington, MA 02090
for fastest registration fax to: (617) 329-8090

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Flight-Test Fixture for Aerodynamic Research

This fixture has been used at airspeeds up to mach 2.0.

Dryden Flight Research Center, Edwards, California

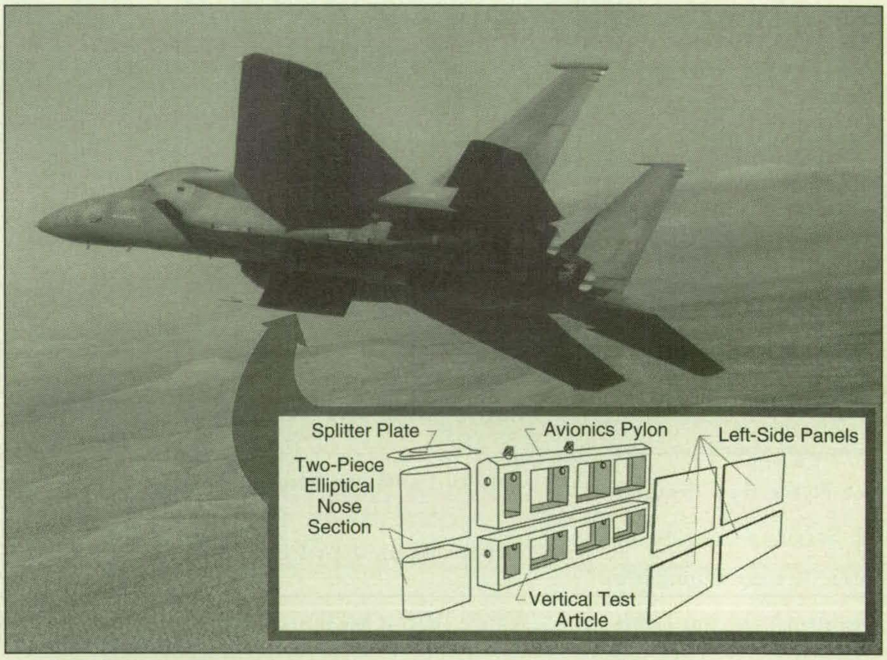
Engineers at the NASA Dryden Flight Research Center have developed a second-generation flight-test fixture (FTF-II) to be used as a generic test bed for research in aerodynamics and fluid mechanics. The FTF-II (see figure) is a low-aspect-ratio, finlike structure mounted on the centerline of the lower fuselage surface of an F-15B airplane. The fixture is 107 in. (272 cm) long, 32 in. (81 cm) high, and 8 in. (20 cm) wide with a 12° elliptical nose section and a blunt trailing edge. Built primarily of carbon/epoxy materials, the fixture consists of a pylon with replaceable side panels, nose section, and a vertical test article.

A modular configuration makes it possible to modify the FTF-II to satisfy a variety of flight-test requirements. The upper 19 in. (48 cm) of the FTF-II is occupied by the avionics pylon, which is a permanent structure that houses avionics, permanent research instrumentation systems, and other support equipment common to most flight experiments. The lower 13 in. (33 cm) of the FTF-II is the vertical test article, which, in the current configuration, matches the contour of the avionics pylon. The vertical test article is removable and can be replaced by vertical test articles of other aerodynamic shapes. Normally, only instrumentation specific to individual research experiments is installed in the vertical test article.

Flush external fasteners provide for quick removal of four left-side panels for access to interior compartments. Two right-side panels extend the length of the fixture and are attached by internal fasteners, which minimize discontinuities for aerodynamic experiments such as surface-flow-visualization studies. The 12° elliptical nose section is located in the forward 18.8 in. (48 cm) and comprises two pieces — one for the avionics pylon and one for the vertical test article. Each piece of the elliptical nose section can be installed or removed independently of the other. To improve the quality of the airflow around the FTF-II, a removable pylon fairing and a splitter plate were installed on the upper portion of the fixture. When needed, a removable air-data probe can be installed near the bottom of the piece of the nose section on the vertical test article.

Because the FTF-II has self-contained research capabilities, the only additional external support essential for operation is electric power from the airplane. The FTF-II uses a 12-bit pulse-code-modulation system capable of multiplexing data at frequencies as high as 200 Hz, depending on the number of data channels. Flight data are transmitted to the ground for storage and postprocessing. A tape recorder in the F-15B airplane is used for backup or to record high-frequency data for a specific flight experiment. Standard FTF-II instrumentation includes a removable air-data probe, load cells to monitor in-flight side loads, flush static-pressure orifices, internal accelerometers (4), and temperature sensors.

The FTF-II has already been used in several flight-research experiments and is now operational and available for potential use by industry and universities. The FTF-II and the F-15B airplane on which it was mounted performed successfully in recent flight tests in which the maximum airspeed was increased to mach 2.0. The results of handling-quality tests of this F-15B/FTF-II combination were similar to those of an F-15 airplane configured with a centerline tank, and included sufficient aircraft directional stability. Flow-pressure surveys and flow-visualization studies revealed flows of good quality throughout the range of speeds and other flight conditions.



The **FTF-II** is a highly instrumented finlike structure mounted on the lower fuselage surface of the F-15B airplane.

This work was done by David M. Richwine of PRC Inc. and John H. Del Frate of **Dryden Flight Research Center**. *For further information,* ***write in 95*** *on the TSP Request Card.*
DRC-95-27

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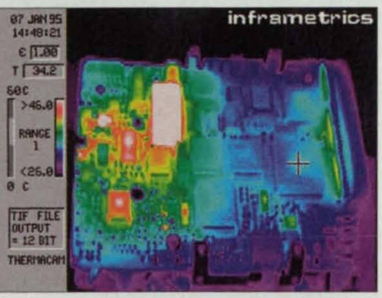

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For More Information Write In No. 540

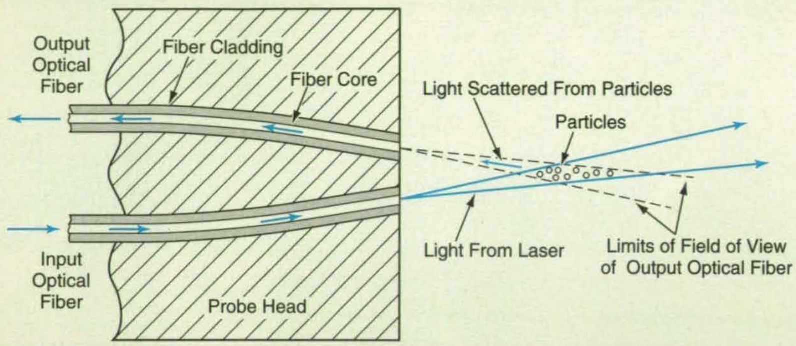
Dynamic Light Scattering With Improved Fiber-Optic Probes

Rugged probes can be used in concentrated suspensions to measure particle-size distributions.

Lewis Research Center, Cleveland, Ohio

Improved fiber-optic probes have been developed for use in dynamic light-scattering measurements. More particularly, the probes are intended for measuring dynamic backscattering of laser light from concentrated suspensions of particles in liquids, for the purpose of determining statistical distributions of sizes of the particles. Such determinations are important for monitoring and controlling many industrial processes.

Conventional light-scattering apparatuses are too bulky and delicate for routine use in hostile environments like those of industrial processes. Further-more, conventional systems yield useful data on dilute suspensions only; the large amount of multiple scattering of light in concentrated suspensions complicates the light-scattering physics to such a degree that there is no practical way to interpret the light-scattering data correctly.



Particles Illuminated via the Input Fiber scatter light in various directions, including toward the output fiber. Particle-size distributions can be determined from dynamic light-scattering measurements.

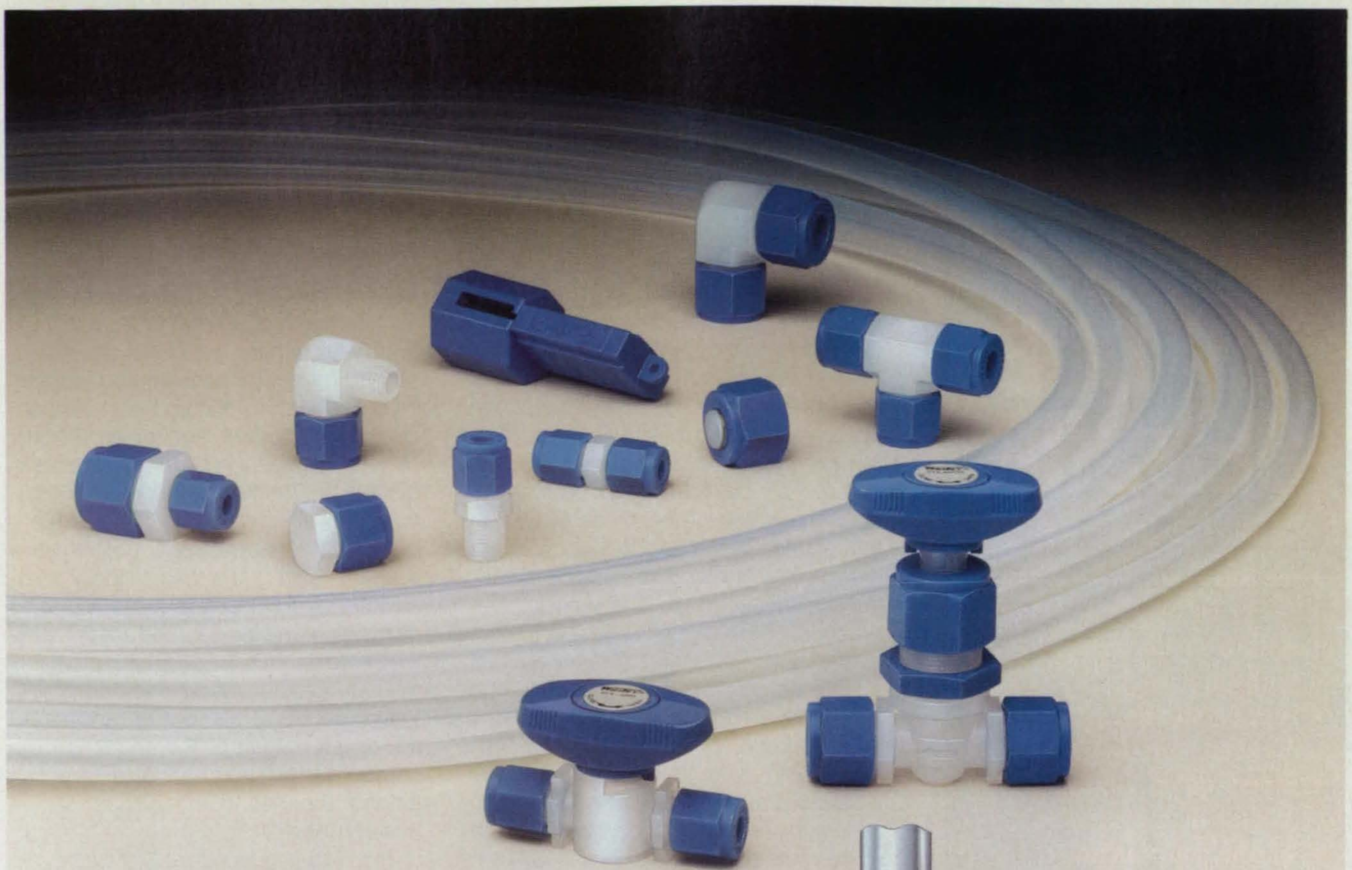
Fiber-optic probes offer the obvious advantages of compactness and ruggedness, and are thus more suitable for industrial environments. Fiber-optic probes can even be immersed in the suspensions to be characterized. The associated lasers, photodetectors, and signal-processing circuits can be located remotely in safer environments, coupled to the probes via optical fibers.

With improved fiber-optic probes, the backscattering regime of operation was chosen because the receiving and detection paths traveled by the photons are so short that the amount of multiple scattering is negligible in the back-scattering direction. A fiber-optic probe of older design contains a single optical fiber that both carries the laser light into the scattering medium and carries the scattered light back to the photodetectors. Many problems are associated with this design and they include mechanical complexity and fragility.

In a fiber-optic probe of the improved type, there are two monomode optical fibers: one fiber carries the laser light into the scattering medium, while the other carries the scattered laser light to a photomultiplier. A digital correlator computes the temporal correlation of intensities as represented by the photon-pulse-train output of the photomultiplier. Inversion of the autocorrelation data leads to the particle-size distribution.

The use of two fibers makes it possible to measure backscattering at an angle that differs enough from 180° to eliminate the scattered-light/laser-light ambiguity, yet is close enough to 180° to suppress multiple scattering. Also, by choice of both the angle and the distance between fibers, one can select not only the scattering angle but also the location of the center of the scattering region at the intersection of the optical axes of the two fibers.

This work was done by Harbans Singh Dhadwal of the State University of New York, Rafat R. Ansari of Case Western Reserve University, and William V. Meyer of the Ohio Aerospace Institute for **Lewis Research Center**. *For further information,* ***write in 73*** *on the TSP Request Card. LEW-15461*



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For More Information Write In No. 541

Measuring Fluxes of Heat to a Plasma-Arc Anode

Three probes yield data on conduction, convection, and radiation of heat to the anode.

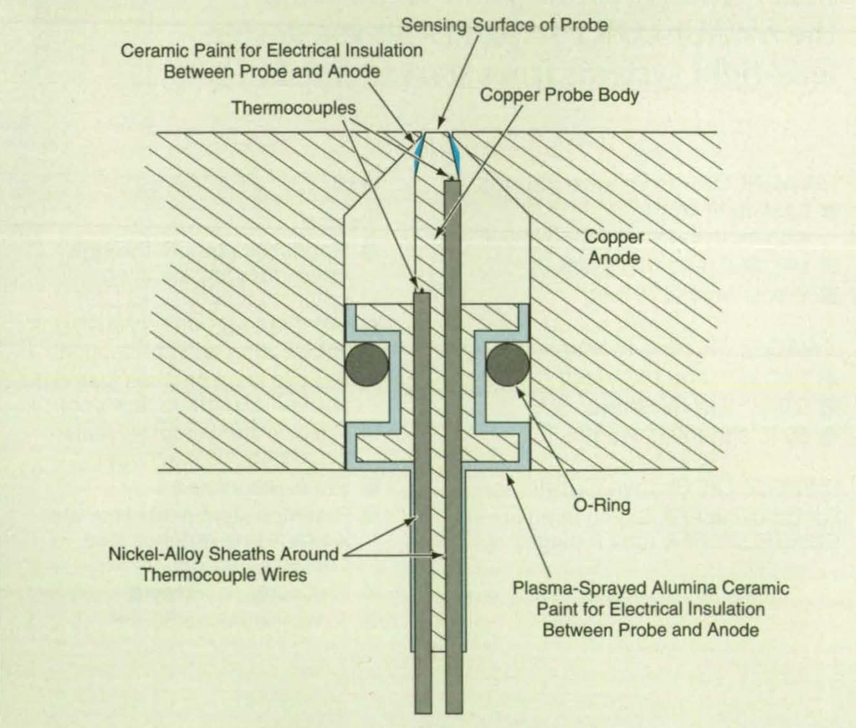
Lewis Research Center, Cleveland, Ohio

Three probes have been constructed to provide measurements indicative of the conductive, convective, and radiative transfer of heat from a free-burning plasma arc to a water-cooled copper anode used in generating the arc. During a plasma experiment, one of these probes is installed in a cavity in the anode, with the sensing surface of the probe flush with that surface of the anode that faces the plasma (see figure). The probe is electrically insulated from the anode; the potential of the probe is allowed to float at the potential of the plasma so that there is no spurious heating of the probe by impact of electrons.

Each probe consists mainly of a copper body with two thermocouples embedded at locations 4 mm apart along its length. The thermocouples provide a measure of the rate of conduction of heat along the probe and thus the transfer of heat from the plasma to the sensing surface at the tip of the probe. The three probes are identical except that the sensing surface of one is uncoated and the sensing surfaces of two of them are coated with different materials to make them sensitive to different components (conductive, convective, and radiative) of the overall flux of heat.

The probe with the uncoated (copper) tip is designed to absorb the same conductive, convective, and radiative fluxes of heat as does the surrounding area of the anode. The tip of one probe is coated with platinum to make it sensitive primarily to the conductive and convective fluxes. The tip of the third probe is coated with carbon black to make it absorb nearly all of the incident radiant flux plus the same conductive and convective flux as that into the platinum-coated probe. The conductive, convective, and radiative fluxes of heat to the anode can be computed by computing differences among the heat-flux readings of the three probes.

This work was done by John M. Sankovic of **Lewis Research Center** *and James A. Menart, Emil Pfender, and Joachim Heberlein of the University of Minnesota. For further information,* ***write in 7*** *on the TSP Request Card. LEW-16076*



A **Heat-Flux-Measuring Probe** (one of three nearly identical probes) is installed in an anode to measure some of the components of the flux of heat from a plasma to the anode.

Polyimides Made From PDMDA

Advantages over commercial polyimides include lower dielectric constants and greater degrees of transparency.

Langley Research Center, Hampton, Virginia

Thermally stable linear aromatic polyimides with improved optical, electrical, and processing characteristics have been made from 3,3′-bis(3,4-dicarboxyphenoxy)diphenylmethane dianhydride (PDMDA). These polyimides can be made in the form of powders that can be dissolved to cast thin films. They are potentially useful as coating and matrix materials. Films made of these polyimides vary from transparent to pale yellow, whereas typical commercial polyimides are bright yellow. The dielectric constants of these polyimides at a frequency of 10 GHz range from 2.7 to 3.1 (vs. 3.2 to 4.0 for typical commercial polyimides). The greater degrees of transparency and lower dielectric constants make these polyimides more suitable for use in some electronic and optical applications; e.g., as insulating materials on wires and protective films on solar photovoltaic cells.

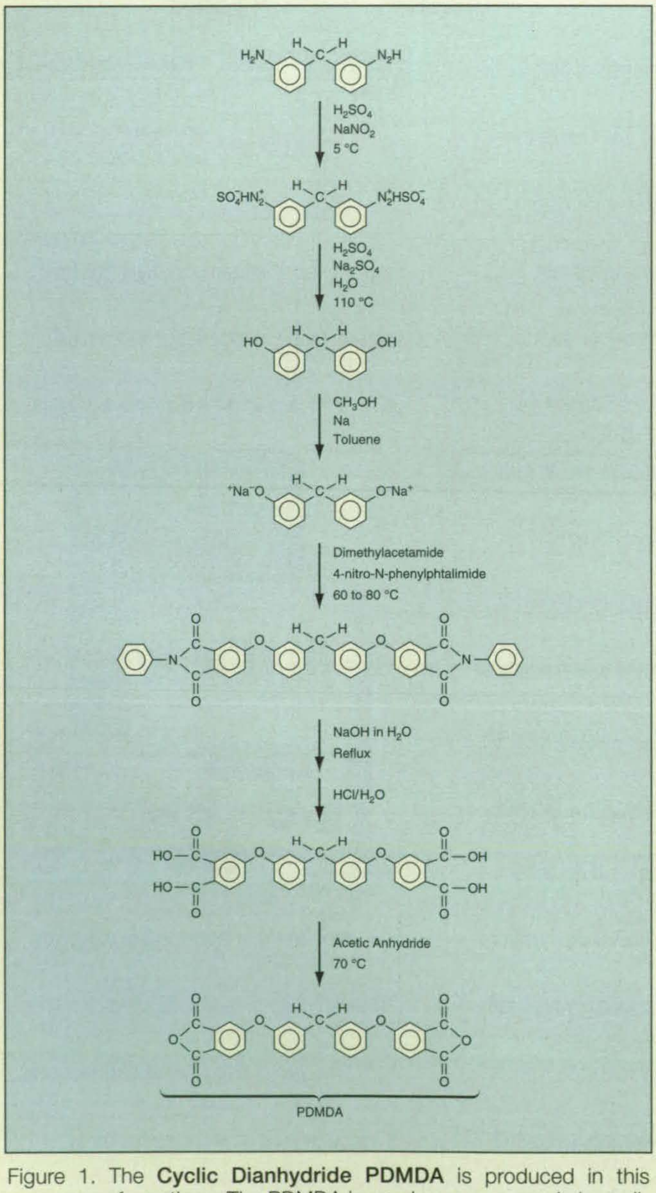


Figure 1. The **Cyclic Dianhydride PDMDA** is produced in this sequence of reactions. The PDMDA is used as a monomeric ingredient in the synthesis of novel linear aromatic polyimides that have relatively low dielectric constants and enhanced optical clarity.

Figure 1 illustrates the synthesis of PDMDA. In the first three steps, 3,3′-diaminophenylmethane is converted to a disodium

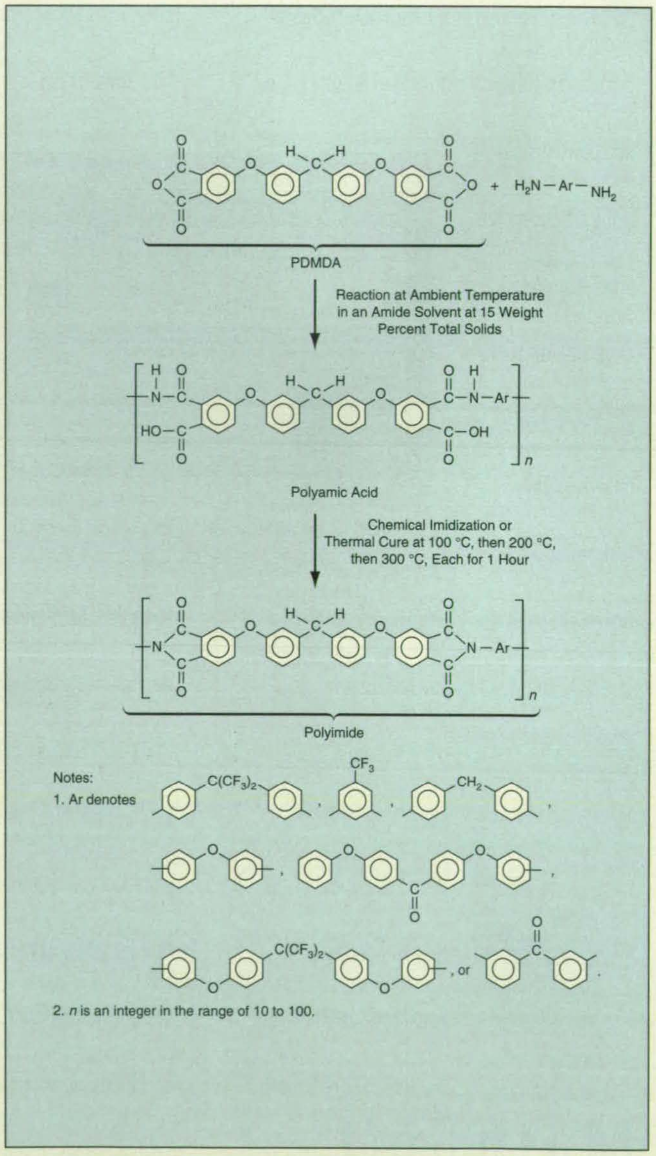


Figure 2. A **Linear Aromatic Polyimide** is synthesized from PDMDA in this sequence of reactions.

bisphenol salt. The salt is reacted with 4-nitro-N-phenylphthalimide, the products of this reaction are refluxed in NaOH to remove the bis-aniline, and the remaining product is hydrolyzed to convert it to a tetracarboxylic acid. The acid, in turn, is reacted with acetic anhydride. The PDMDA precipitates and is dried in vacuum.

Figure 2 illustrates the synthesis of a polyimide from PDMDA. An aromatic diamine in an amide solvent is mixed with an equal molar portion of PDMDA and the mixture is stirred at ambient temperature in a closed vessel. The reaction between the aromatic diamine and the PDMDA forms a polyamic acid, which can be converted to the polyimide and used in either of two ways: The solution of polyamic acid and amide solvent can be cast into a thin film, then heated to evaporate the solvent and thermally convert the polyamic acid film to the desired polyimide film. Alternatively, the polyamic acid in solution can be chemically imidized and precipitated to obtain the polyimide in the form of a powder, which can later be redissolved and applied as a coating or film.

This work was done by Anne K. St. Clair of **Langley Research Center** *and Harold G. Boston and John R. Pratt of Lockheed Engineering & Sciences Corp. For further information,* ***write in 143*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,218,077). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-14487.

Improved Preparation of Solid-Electrolyte Films

A modified process ensures compatibility among components.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved chemical-blending procedure produces a composite material for thin, large-area solid-electrolyte films for lithium batteries. The films have uniform compositions and are dimensionally stable. The transport number of their lithium cations is high, close to unity. Batteries made with these films are expected to have energy and power densities up to about 100 W•h/kg and 100 W/kg, respectively.

A previous version of the composite material was described in "Composite Solid Electrolyte for Lithium Cells" (NPO-18694), *NASA Tech Briefs*, Vol. 18, No. 7 (July 1994), page 49. The composite material is a combination of polyethylene oxide, alumina, and lithium iodide ($PEO/Al_2O_3/LiI$). Previous attempts to make the composite by dissolving constituents one at a time in an acetonitrile solution were only partially successful in that as soon as PEO was added to the mixture containing the other ingredients, the alumina particles became agglomerated into balls covered with PEO. Therefore, the films made with the composite material did not have a uniform composition.

An experiment showed that agglomeration could be prevented by adding isopropyl alcohol to the mixture before adding PEO. The alcohol apparently inhibits the scavenging action of PEO.

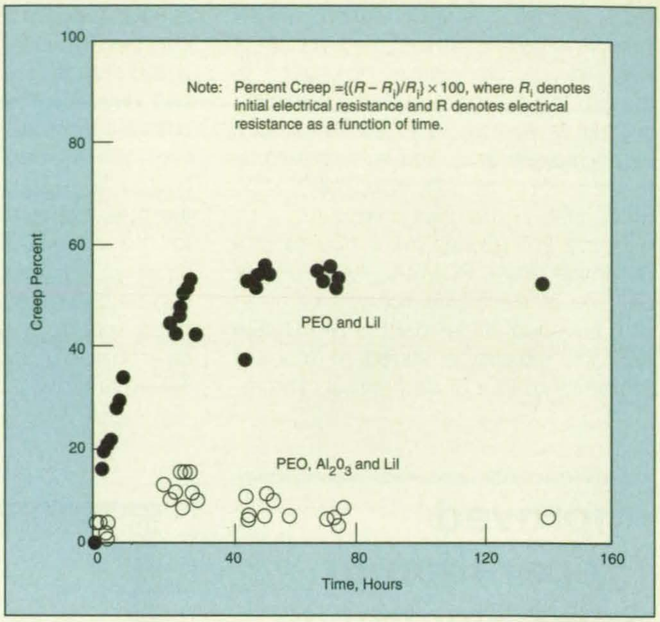
The experiment involved the following steps:

- Appropriate amounts of LiI, Al_2O_3, and PEO were weighed out separately.
- The LiI was dissolved in 50 mL of acetonitrile.
- The alumina was added to the LiI/acetonitrile solution and stirred for 5 min.
- 80 mL of isopropyl alcohol were added to the solution and stirred well. Another 120 mL of acetonitrile were stirred in, followed by 80 mL more of the alcohol.
- While the solution was stirred vigorously, the PEO was added. Stirring was continued overnight to dissolve the PEO.

The particles of alumina in the resulting mixture were found to be suspended uniformly. An electrolyte film cast from this mixture exhibited remarkable dimensional stability. In thermal-creep measurements, the PEO/Al_2O_3/LiI film was found to be more stable than was a similar film that did not contain alumina particles (see figure).

This work was done by Ganesan Nagasubramanian and Alan Attia of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 118*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL; (818) 354-5179. Refer to NPO-18877.



Composite of Polyethylene Oxide, Alumina, and Lithium Iodide exhibited much less creep than did a composite that did not include alumina.

Mathematical Model of Curing Behavior of a Polymer

The model predicts chemical, thermal, and mechanical responses.

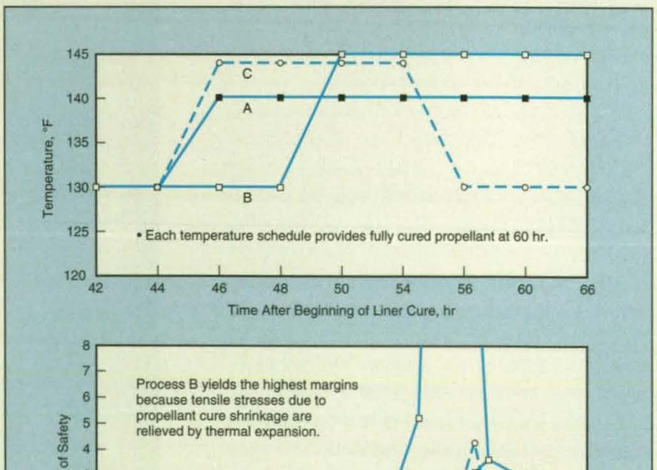
Marshall Space Flight Center, Alabama

A mathematical model predicts selected aspects of the chemical, thermal and mechanical responses of polymeric liner and propellant materials during a curing process. Predictions can be made both prior to processing and during the process in quasi-real time. The model was developed specifically for use in designing and analyzing a process in which bondline materials (including polymeric liners) and propellant are cast and cured in a rocket motor. With modifications, the model should be applicable to curing of other polymeric materials.

The one-dimensional model is incorporated in a computer program having three basic modules: (1) a process environment model (PEM) that predicts the current state of cure of the material as well as its chemical and thermal responses; (2) a process mechanical model (PMM) that uses data calculated by the PEM to predict stresses, strains and displacements; and (3) a process assessment model (PAM) that evaluates the chemical, thermal and mechanical responses.

The model can be used to design curing processes that can potentially help reduce the variability of properties often observed in both propellant and bondline materials. This is accomplished by using the model to assess trial process temperature schedules that can alleviate tensile stresses that develop in the bond system due to propellant cure shrinkage. Proper selection of a process schedule will ensure that propellant and bondline tensile stresses due to chemical shrinkage are sufficiently counterbalanced by compressive thermal stresses (caused by increasing the cure temperature after the gel point is reached). To avoid possible processing problems, any net tensile stresses must be kept below the current propellant and bondline strengths. This may necessitate the use of nonisothermal process schedules (see figure). Until now, standard practice in the industry has been to process materials at constant temperatures.

Inasmuch as the simulation of an entire process takes only a few minutes, whereas the actual process often takes days, it is possible to make in-process predictions in quasi-real time. This is done using the actual process temperature to drive model predictions of conditions at the locations of dielectric gauges, thermocouples and stress sensors. Comparison of predicted and measured responses then provides a more comprehensive understanding of bondline property variations and stress states during the process. Further development may provide a direct "in-line" program for calculations, including



Three Equivalent Curing Processes defined by different temperature schedules were applied to a conceptual rocket motor and analyzed by use of the mathematical model described in the text. The lower plot shows the predicted critical margin of safety history for each process (failure is indicated when the margin of safety falls to zero). Process B would be selected.

comparisons, in real time. This will constitute a basis for more sophisticated control of the process.

This work was done by Willard C. Loomis of Science Applications International Corp., Rodney B. Beyer of Atlantic Research Corp., and Edmund K. S. Liu of GenCorp Aerojet for **Marshall Space Flight Center.** *For further information,* ***write in 94*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28876.

Hydrophobic Catalysts for Removal of NO_x From Flue Gases

These catalysts would not be adversely affected by water vapor and sulfur oxides.

NASA's Jet Propulsion Laboratory, Pasadena, California

Improved catalysts for the removal of nitrogen oxides (NO and NO_2) from combustion flue gases would be formulated as composites of vanadium pentoxide in carbon molecular sieves. These catalysts are expected to promote the highly efficient selective catalytic reduction of NO_x at relatively low temperatures while not being adversely affected by the presence of water vapor and sulfur oxide gases in the flue gas. An apparatus that utilizes a catalyst of this type could be easily integrated into the exhaust stream of a power plant (see figure) to remove nitrogen oxides, which are generated in the combustion of fossil fuels and which contribute to the formation of acid rain and photochemical smog (or ozone, which is a pollutant in the lower atmosphere).

Similar to catalysts that have been developed previously for the same purpose, these would promote the reduction of NO_x by ammonia that had been injected into the flue gas. The main chemical reactions for the removal of NO_x are

$$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O,$$

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O,$$

and

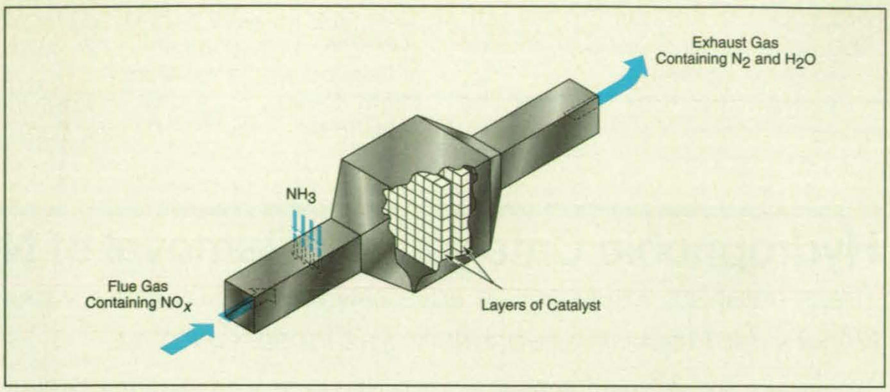
$$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O.$$

Vanadium pentoxide (V_2O_5) is known to be a good catalyst for these reactions. However, the water vapor produced in these reactions has an unfavorable effect on the reduction equilibrium. In addition, the combustion of fuels that contain sulfur produces SO_2, and the catalyst promotes the conversion of a small amount of the SO_2 to SO_3. Then the reaction of NH_3 with SO_3 and H_2O produces $(NH_4)_2SO_4$ and NH_4HSO_4, which eventually accumulate in sufficient quantity to clog the pores of the catalyst support and thereby deactivate the catalyst. This process limits the life of the catalyst which requires either the replacement or regeneration of the catalyst. Thus, it would be desirable to develop a hydrophobic catalyst to minimize the effect of water vapor and at the same time make the catalyst minimally susceptible to clogging by sulfates and thereby extend the life of the catalyst.

Although not usually hydrophobic, activated charcoal can catalyze the reduction of NO_x at temperatures as low as 100 °C. Recently, carbon molecular sieves (which are hydrophobic) have

been put to new use in separation and purification of gases. Carbon molecular sieves offer an improvement over activated charcoal because of their molecular-sieving characteristics, hydrophobicity, and potentially larger surface areas. Thus, it is proposed to disperse V_2O_5 on high-surface-area supports to obtain fast chemical kinetics and to use carbon molecular sieves as such supporting materials to obtain very effective catalysts for the reduction of NO_x.

It should be possible to prepare the proposed catalysts by a modified version of a method used previously to make a hydrophobic composite of silicalite and carbon molecular sieve for removal of selected organic compounds. In addition, carbon molecular sieves can be made with pore sizes of 3 to 4.0 Å, so that it should be impossible for SO_2 and SO_3 (and heavy aromatics, if present) to enter the pores, as their respective sizes are greater than 4.0 Å. This will prevent the formation of sulfates inside the pores.



A **Catalyst in the Flue** would promote the reduction of NO_x by ammonia to harmless N_2 and H_2O.

It is expected that V_2O_5/carbon-molecular-sieve catalysts will function in the temperature range 175 to 350 °C, where there is a significant reduction of NO_x. Operation at the low end of this temperature range should be possible without encountering plugging of pores or poisoning of the catalysts. The high temperature limit reflects the possible oxidation of carbon in the catalyst at temperatures above 350 °C.

This work was done by Pramod K. Sharma, Gregory S. Hickey, and Gerald E. Voecks of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 45*** *on the TSP Request Card. NPO-19474*

Wire-Arc-Sprayed Aluminum Protects Steel Against Corrosion

Unlike some paints, aluminum coatings do not emit chromium and volatile organic compounds.

Marshall Space Flight Center, Alabama

Aluminum coatings wire-arc sprayed onto steel substrates have been found to be effective in protecting the substrates against corrosion. These aluminum coatings also satisfy stringent requirements for adhesion and flexibility, both at room temperature and at temperatures as low as that of liquid hydrogen [–423 °F (–253 °C)]. The wire-arc-sprayed aluminum coatings were developed as alternatives to corrosion-inhibiting primers and paints that are required by law to be phased out because they contain and emit such toxic substances as chromium and volatile organic compounds.

Wire-arc spraying offers important advantages over other thermal deposition processes and over painting. Unlike in painting, there is no need for drying or curing time. In comparison with other thermal processes, the substrates can be kept at relatively low temperatures, and rates of deposition are high.

An aluminum coating forms a galvanic cell with a steel substrate, the steel acting as the cathode and the aluminum as the anode. In this arrangement, the aluminum corrodes preferentially, thus protecting the steel.

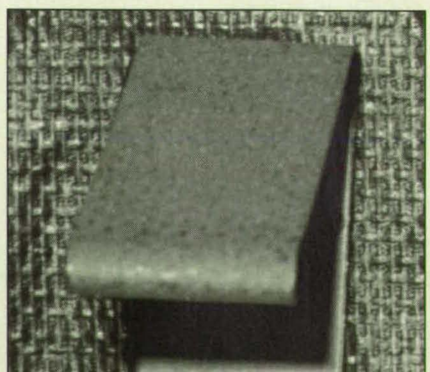
In an experiment, aluminum coatings were wire-arc-sprayed on plates and on a duct made of 21-6-9 corrosion-resistant steel, then the plates and duct were tested as follows:

- Adhesion and flexibility at room temperature. The aluminum coating did not crack when the plate was bent around a mandrel of 0.3-in. (7.6-mm) diameter. The plate was then subjected to a tape-pull test, and the coating continued to adhere (see figure).
- Adhesion and flexibility at low temperature. A plate submerged in liquid nitrogen at –320 °F, (–196 °C) was bent around a mandrel of 2.8-in. (71-mm) diameter without cracking or loss of adhesion of the aluminum coat.
- Resistance to corrosion. Plates survived 120 days in a salt fog, without corrosion or pitting of the substrate.
- Thermal shock. By turning a flow of liquid hydrogen on and off, the duct was thermally cycled to –423 °F (–253 °C) 17 times in 16 hours. The aluminum coating did not crack or lose adhesion.

The optimum aluminum-coating thickness has been found to lie between 0.004 and 0.008 in. (between 0.1 and 0.2 mm). Thicker coats are less flexible and tend to blister in salt-fog tests. Grit blasting to prepare substrates for adhesion of wire-arc sprayed aluminum is unnecessary and may be unacceptable in situations in which substrates are required to be smooth; hand sanding has been found to result in the required degree of adhesion.

This work was done by Frank R. Zimmerman and Richard Poorman of **Marshall Space Flight Center** *and Heather L. Sanders, Timothy N. McKechnie, James W. Bonds, Jr., and Ronald L. Daniel, Jr., of Rockwell International Corp. For further information,* ***write in 96*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-30044.



This **Specimen Was Bent** and subjected to a tape-pull test, without cracking or loss of adhesion of its wire-arc-sprayed aluminum coating.

Eutectic-Free Superalloy Made by Directional Solidification

Resistance to fatigue is enhanced.

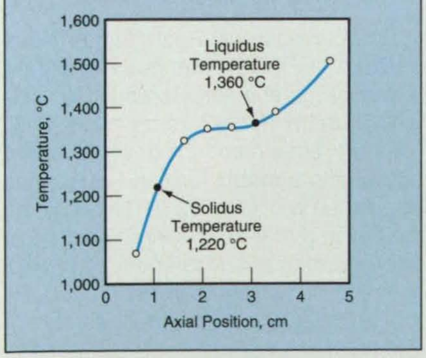
Marshall Space Flight Center, Alabama

By suitable control of the thermal conditions in a directional-solidification pro-cess, superalloy structural and machine components (e.g., turbine blades) can be cast with microstructures that enhance resistance to fatigue. The specific version of the process and the thermal conditions are chosen to reduce microsegregation during solidification and to minimize or eliminate script carbide and eutectic-phase inclusions, which are brittle inclusions that have been found to decrease resistance to fatigue.

Numerous variations on the basic directional-solidification theme have been described previously in *NASA Tech Briefs*. Typically, a batch of the alloy in question is melted under an inert atmosphere in a cylindrical crucible, then progressively resolidified, from one end to the other. This is accomplished by use of a hollow cylindrical furnace that fits closely but loosely around the crucible and translates along the crucible.

The melt-zone temperature and the axial gradient of temperature at and near the moving solidification front affect the microstructure of the solidified alloy. To make it possible to tailor the spatial distribution of temperature to optimize the microstructure, the furnace is constructed with a chilling block at one end, plus multiple, axially spaced heaters that can be maintained at different temperatures. The speed of translation also affects the outcome and should be adjusted accordingly.

The concept has been verified in experiments on the nickel-base superalloy Mar-M246(Hf). The figure shows the axial temperature profile that, along with a rate of translation of 30 cm/h, has been found to give the best results for this alloy. Specimens that were directionally solidified under these conditions exhibited microstructures with small, closely spaced dendrite arms (which inhibit microsegregation); fine, blocky carbides; and no eutectic phase. These directionally solidified specimens were also heat treated and subjected to high-cycle-fatigue tests. Statistical analysis of the results of these tests revealed that these specimens had fatigue lives about ten times those of other specimens of the same alloy that were directionally solidified in the same furnace with a nonoptimum temperature profile.



This **Axial Temperature Profile**, translated along a specimen of Mar-M246(Hf) at a speed of 30 cm/h, produces a eutectic-free microstructure that imparts high resistance to fatigue.

This work was done by Deborah Dianne Schmidt of **Marshall Space Flight Center.** *For further information,* ***write in 12*** *on the TSP Request Card.* MFS-31030

Computer Programs

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Mathematics and Information Sciences

Program Computes SLM Inputs To Implement Optimal Filters

MEDOF optimizes values for filters in optical correlators.

The Minimum Euclidean Distance Optimal Filter (MEDOF) program generates filters for use in optical correlators. The algorithm implemented in MEDOF follows the theory put forth by Richard D. Juday in "Optimal realizable filters and the minimum Euclidean distance principle," *Applied Optics*, Vol. 32 (September 10, 1993), pp. 5100-5111. This program analytically optimizes filters on arbitrary spatial light modulators (SLMs) of such types as coupled, binary, fully complex, and fractional-2π-phase. MEDOF optimizes filters constructed on these modulators for a number of metrics including the following:

- Intensity of the correlation peak at the origin for the centered appearance of the reference image in the input plane;
- The signal-to-noise ratio (SNR), including the correlation-detector noise as well as the colored additive input noise;
- The peak-to-correlation-energy ratio (PCE) defined as the fraction of the signal energy passed by the filter that shows up in the correlation spot; and
- The peak-to-total-energy ratio, which is a generalization of PCE in which the passed colored input noise is added to the passed energy of the input image.

The user of MEDOF supplies the functions that describe the following quantities:

- The reference signal;
- The realizable complex encodings of both the input and filter SLM;
- The noise model, possibly colored, as it adds at the reference image and at the correlation detection plane; and
- The metric to analyze, here taken to be one of the analytical ones like SNR or PCE. MEDOF does not directly optimize such nonanalytic metrics as the peak-to-secondary ratio.

MEDOF examines the statistics of the noise of the encoded input (if SNR or PCE is selected) and the available values of the filter SLMs. These statistics are used to determine a range for searching for the magnitude and phase of *k*, a pragmatically based complex constant necessary for computing the optimal filter. The filter is produced for the mesh points of *k* and the value of the metric that results from these points is computed. When the search is concluded, the values of amplitude and phase of that *k*, the metric of which is largest, as well as consistency checks, are reported.

A finer search can be done in the neighborhood of the optimal *k* if desired. The filter finally selected is written to disk in terms of voltages to be applied to SLMs, not in terms of the complex transmittance of the filter. Optionally, the impulse response of the filter can be created to enable the user to examine the responses in the cases of the features the algorithm selects as important to the recognition process under the selected metric, limitations of the filter SLM, etc. Because MEDOF uses the filter SLM to its greatest potential, the filter competence is not compromised for simplicity of computation.

MEDOF is written in C language for Sun-series computers running SunOS. With slight modifications, it has been implemented on DEC VAX-series computers using the DEC-C v3.30 compiler, although the documentation does not currently support this implementation. MEDOF can also be compiled by use of Borland International, Inc., Turbo C++ v1.0, but IBM PC memory restrictions greatly reduce the maximum size of the reference images from which the filters can be calculated. MEDOF requires a two-dimensional fast Fourier transform (2DFFT). One 2DFFT routine that has been used successfully with MEDOF is a routine found in "Numerical Recipes in C: The Art of Scientific Programming," which is available from Cambridge University Press, New Rochelle, NY 10801. The standard distribution medium for MEDOF is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. MEDOF was developed in 1992-1993.

This program was written by R. Shane Barton, Richard D. Juday, and Jennifer L. Alvarez of **Johnson Space Center**. *For further information,* ***write in 211*** *on the TSP Request Card. MSC-22380*

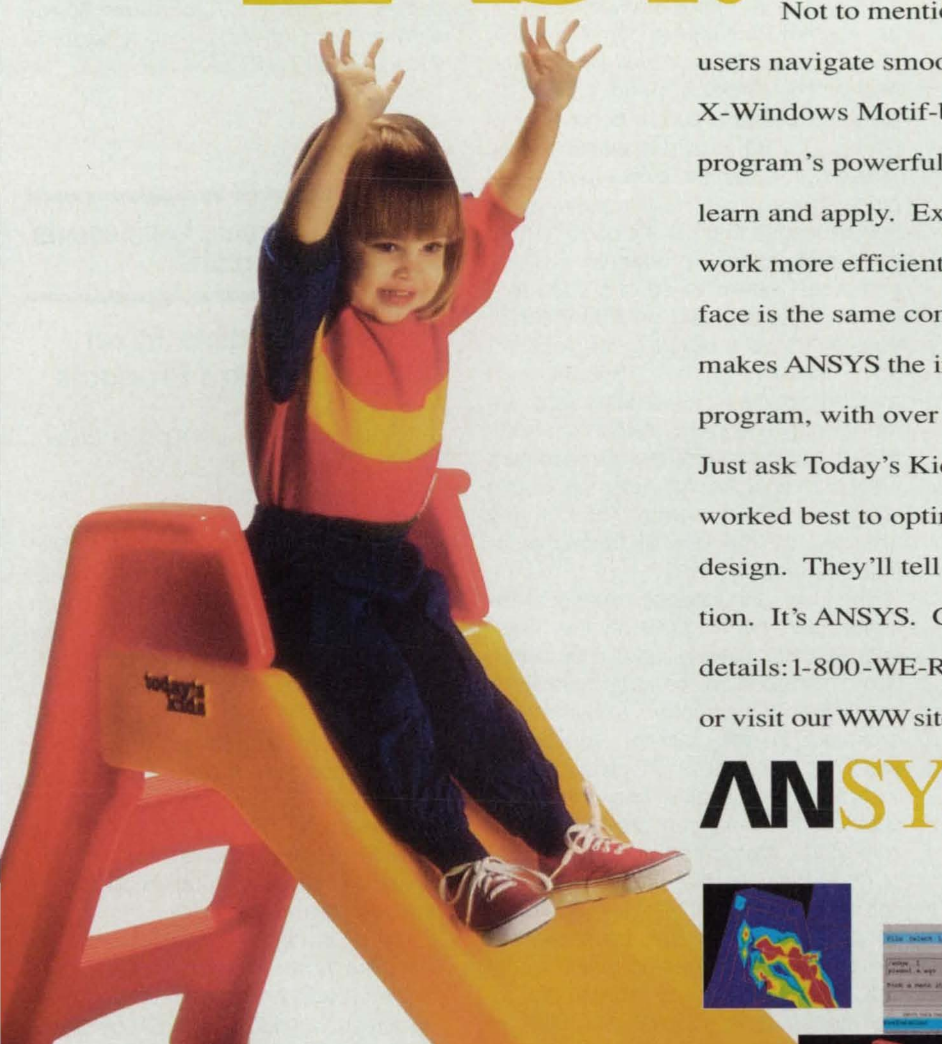
Mathematics and Information Sciences

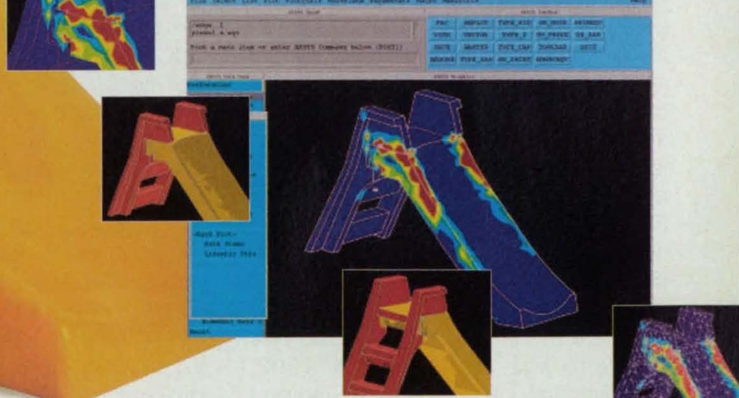
Program for Analyzing Failures in a Complex System

CRANS facilitates rapid logic-tree analysis.

The Configurable Real-Time Analysis System (CRANS) computer program provides means for representing logically interconnected items (e.g., modules of equipment in a complicated system) in a matrix format. Capabilities like those provided by CRANS can be helpful in a real-time environment (e.g., the operational environment of such a system), in which there is a need for quick evaluation of the results of changes or failures.

Tabulations that show the effects of changes and/or failures of a given item in the system are generally useful only for a single input, and only with regard to





ANSYS FEA model constructed from a Pro/ENGINEER® assembly accurately showed that large, nonlinear deflections tripled the maximum stresses in the slide handrail.

that item. Subsequent changes become more difficult to evaluate as combinations of failures produce a cascade effect. In the presence of multiple indicated failures in the system, it becomes necessary to determine a single cause. In this case, failure tables are not very helpful.

CRANS can interpret a logic tree that has been constructed by the user to describe a complex system and can determine the effects of changes and failures in the system represented by the logic tree. Items in the tree are related to each other by Boolean operators. The user is then able to change the states of these items (ON/OFF FAILED/UNFAILED). The program then evaluates the logic tree as thus amended and determines any resultant changes to other items in the tree. In this way, CRANS exceeds the capability of a simple failure table since multiple failures/changes can be input simultaneously. CRANS can also search for a common cause of failures of multiple items, and enables the user to explore the logic tree from within the program.

Display output is in the form of a matrix or matrices of colored boxes defined by the user, each box representing an item or set of items from the logic tree. Input is via mouse selection of the matrix boxes, using the mouse buttons to toggle the state of each affected item.

CRANS is written in C language and requires revision 4 or revision 5 of version 11 of the MIT X Window System. It requires 78K of random-access memory for execution (the amount of memory needed depends on the size of the logic tree), and a three-button mouse. It has been successfully implemented on Sun4 workstations running SunOS, HP9000 workstations running HP-UX, and DECstations running ULTRIX as well as on DEC Alpha, Silicon Graphics, and Masscomp 6600. No executable code is provided on the distribution medium; however, a sample makefile is included. Sample input files are also included. The standard distribution medium is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available upon request. This program was developed in 1992. (The original version was developed in 1989.)

This program was written by R. Kevin McCluney of **Johnson Space Center**. *For further information,* ***write in 210*** *on the TSP Request Card. MSC-21845*

Mechanics

P-Finite-Element Program for Analysis of Plates

Results can be more accurate than in the h-finite-element method.

BUCKY is a p-finite-element computer program for highly accurate analysis of structures. BUCKY can be used to analyze the buckling, bending, and in-plane stress-and-strain behaviors of plates. BUCKY provides elastic-plastic solutions for isotropic plates in states of plane stress, and an axisymmetric solution sequence that can be used to treat three-dimensional problems. BUCKY computes the response of a plate to a variety of loading and boundary conditions by use of a higher-order displacement function in the p-finite-element method. Several h-elements can be replaced by a single p-element. In addition, the high order of the displacement functions enables the user to obtain results more accurate than those obtained by the use of traditional h-finite elements.

The user can choose among plane stress, plate bending (Kirchhoff or Reissner-Mindlin theory), plate buckling, two-dimensional plane-stress plasticity, and three-dimensional axisymmetric analysis. In the current version of BUCKY, the thickness of a plate can vary linearly in the spatial coordinates. In addition, the user can prescribe pressure loads, distributed edge moments, or edge tractions that are constant, linear, or quadratic in behavior. For plate bending, loads can also be applied in the form of concentrated point loads. BUCKY also supports orthotropic as well as isotropic material properties at the element level.

BUCKY is written in FORTRAN 77 for UNIX-based computers. It has been successfully implemented on HP9000-series 700/800 computers running HP-UX 8.07, Sun4-series computers running SunOS 4.1.1, SGI IRIS-series computers running IRIX 5.2, and CRAY Y-MP-series computers running UNICOS 5.1. COSMIC was unsuccessful in implementing BUCKY on a DECstation 3100 computer running DEC RISC ULTRIX 4.3. BUCKY requires 5MB of disk space for installation. The amount of random-access memory (RAM) needed varies with the size of the problem being solved; however, 10MB of RAM is needed for this version of the source code. In addition to primary output files, BUCKY produces PATRAN and I-DEAS Universal output files for post-processing. An electronic version of the documentation is included on the distribution medium in PostScript format. The standard distribution medium for BUCKY is a 0.25-in. (6.35-mm) streaming-magnetic tape cartridge (Sun QIC-24) in UNIX tar format. BUCKY was originally developed In 1992 and released in 1994.

This work program was written by James P. Smith of **Johnson Space Center**. *For further information,* ***write in 21*** *on the TSP Request Card. MSC-22470*

Electronic Components and Circuits

Program Predicts Mixer Intermodulation Products

This interactive program aids design and analysis of frequency converters.

IMODP is a computer-aided-design (CAD) software tool useful in the analysis and design of frequency-conversion schemes. Frequency conversion or mixing is an essential function in communication receivers, down-converters, and transmitters. IMODP analyzes the intermodulation products created by mixing of (1) harmonics of a local-oscillator (LO) signal with (2) harmonics of another radio-frequency (RF) signal. Such mixing results in signal components in the intermediate-frequency (IF) range above the required rejection level.

IMODP is highly interactive with the user. The user is prompted for inputs and is provided outputs in real time on the screen. In addition, IMODP creates a file in which the output is saved. The inputs that IMODP accepts are the ranges and increments of the frequencies of the LO and the other RF signal, the nominal IF and the IF bandwidth, the shape of the IF filter, the required level of rejection of intermodulation products, the highest (up to 10) order of harmonic to be calculated, and the specific mixer intermodulation-product-suppression table. The user can insert a new table (guided by the program) or select one of the standard tables provided.

In order to facilitate the efficient iteration process necessary for complex frequency schemes, the program provides configuration files that store last-run inputs. The program offers last-run val-

ues as default inputs so that the only parameters that must be entered are those with new values.

Output from IMODP consists of a list of all input parameters and a list of all the frequencies and levels of all intermodulation products, the levels of which exceed the required suppression levels. The suppression that is calculated includes the mixer suppression as well as the IF-band-pass-filter rejection. This filter is assumed to have zero loss in the pass band and linear slopes with respect to frequency.

IMODP is written in Microsoft FORTRAN for IBM PC-series and compatible computers running MS-DOS. This software package includes a sample executable code compiled by use of Microsoft FORTRAN v4.0. IMODP requires approximately 36K of random-access memory for execution. The standard distribution medium for this program is a 3.5-in. (8.89-cm), 1.44MB MS-DOS-format diskette. Documentation is included in the price of the program. IMODP was developed in 1993 and is a copyrighted work with all copyright vested in NASA.

This program was written by Dalia McWatters of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 67*** *on the TSP Request Card. NPO-19379*

Materials

Program Helps Generate Boundary-Element Mathematical Models

Time and effort are reduced significantly.

The Composite Model Generation-Boundary Element Method (COMGEN-BEM) computer program, which was developed in PATRAN Command Language (PCL), can significantly reduce the time and effort needed to construct boundary-element mathematical models of continuous-fiber composite materials at the micromechanical (constituent) scale. Heretofore, in conducting a boundary-element analysis, it was necessary to expend much time and effort in constructing such a model, either manually or by use of a graphical preprocessor. As it saves time and reduces effort, COMGEN-BEM generates boundary-element models that are compatible with the BEST-CMS boundary-element code for analysis of the micromechanics of a composite material.

COMGEN-BEM operates within the computing environment of the PATRAN graphical preprocessor software. COMGEN-BEM generates boundary-element models based on several parameters supplied by the user. Geometric data input includes type of model, fiber volume fraction, diameter of fibers, and thickness of the model. Data on the density of the computational mesh are entered by the user, along with data on properties of materials, orientations (that is, angles) of fibers, and boundary conditions. On the basis of these data, COMGEN-BEM executes the PATRAN model-generation commands required to generate an appropriate boundary-element model.

To request data from the user, COMGEN-BEM issues interactive prompts during execution. The program automatically checks, in most cases, to ensure that a valid parameter has been supplied, and at several points it echoes input data and prompts the user to indicate whether the entered parameters are correct. Once the program completes execution, the generated model is plotted on the computer video screen, and the user can then apply the user's own translator program to convert the model data into an appropriate BEST-CMS input-file format.

COMGEN-BEM is written in PATRAN Command Language (PCL) for use on any computer running PATRAN v2.5. For information on PATRAN v2.5, write to MacNeal-Schwendler Corporation, 815 Colorado Blvd. Los Angeles, CA 90099. This program requires 360K of random-access memory for execution. The documentation for COMGEN-BEM consists of NASA Technical Memorandum 105548 and an addendum, and is available in hard copy as well as in ASCII electronic form on the distribution medium. The figures included in the NASA Technical Memorandum, however, are not included in the electronic documentation. The standard medium for distribution of COMGEN-BEM is a 3.5-in. (8.89-cm) diskette in UNIX tar format. Alternate distribution media and formats are available upon request. COMGEN-BEM was developed in 1993.

This program was written by R. K. Goldberg of **Lewis Research Center.** *For further information,* ***write in 59*** *on the TSP Request Card. LEW-15874*

Mathematics and Information Sciences

Mapping Vegetative Ground Cover from Polarimetric SAR Data

Three-frequency quad-polarization data are used to distinguish among different types of cover.

The MAPVEG computer program performs a first-level classification of NASA/JPL AIRSAR polarimetric synthetic-aperture-radar (SAR) data into simple ground-cover types. Classification images generated by MAPVEG can be used to separate vegetated from nonvegetated areas; this separation may be useful in determining the soil moisture in areas free of vegetation. MAPVEG classification can separate forests from the surrounding vegetation, and can be used to identify clear-cut areas, for example. Urban areas and potential marshlands are examples of other identifiable classes. MAPVEG images can be used in the first stage of a classification scheme more specific to a user's application. For example, having classified an area as one of low vegetation in an agricultural region, one might wish to go on to separate the area into crops of different types.

The classification algorithm in MAPVEG is based on a model fit to the AIRSAR data. This fit provides estimates of the contributions of surface, double-bounce, and volume scatter to the observed polarimetric radar signatures for each of the three wavelengths measured by the AIRSAR. After the model fit has been applied to the data, simple rules (established by training on different ground-cover signatures in just three AIRSAR images) are used to classify the results into one of several different ground cover types. The algorithm used is capable of distinguishing among areas with no vegetation cover, areas with low- and medium-level vegetation cover, forested areas, and urban areas. The three vegetated classes of ground cover are further subdivided into areas where double-bounce scatter is significant and areas where it is not.

The output from MAPVEG consists of a byte image with each class assigned to a different numerical value, plus a header that provides information on the dimensions of the image, a key to the numerical values, and a list of the percentages of the image assigned to each class. The image data are typically much fewer than are the original AIRSAR data (e.g., a 330KB image from 39MB of typical AIRSAR data) and can be easily displayed on a PC or on a Macintosh computer by use of standard image-processing software.

MAPVEG is written in FORTRAN 77 for Sun and DEC VAX computers. It has been successfully implemented on Sun4-series computers running SunOS 4.1.3 and Solaris 2.3, and DEC VAX-series computers running VMS 5.5. The program consists of a single source-code file to be compiled on the appropriate platform, and it requires 2MB of random-access memory for execution. MAPVEG is designed to be used with calibrated three-frequencypolarimetric NASA/JPL AIRSAR radar data in Stokes matrix format. The standard distribution medium for MAPVEG is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Upon request, MAPVEG is also available in DEC VAX BACKUP format on a 1,600-bit/in. (630-bit/cm), 9-track magnetic tape or a TK50 tape cartridge. MAPVEG was developed in 1992 and is a copyrighted work with all copyright vested in NASA.

This program was written by Bruce Chapman and Anthony Freeman of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 65*** *on the TSP Request Card.*
NPO-19335

Mechanics

Self-Regulating Shock Absorber

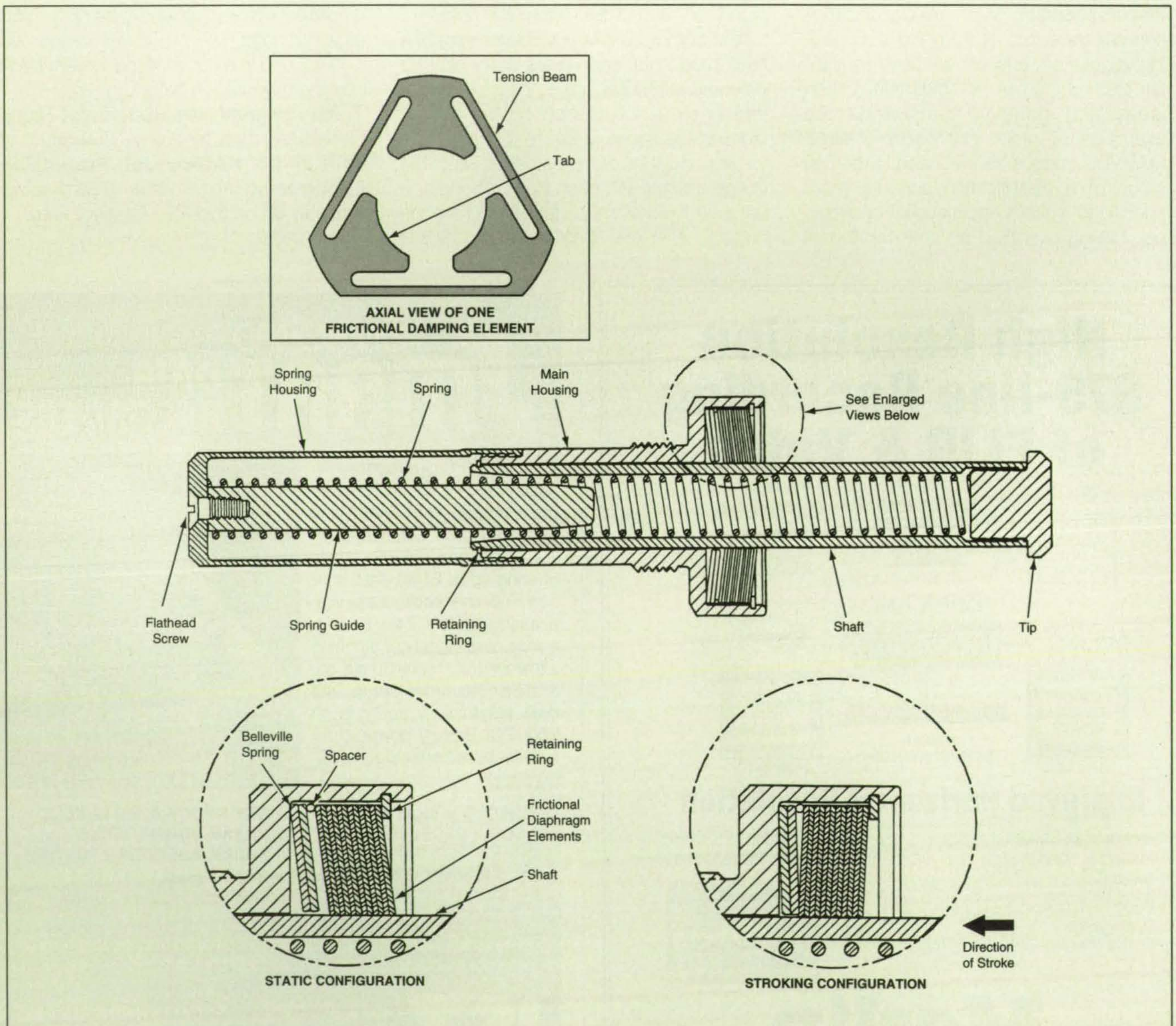
This device reduces its frictional damping force under overload.

Lyndon B. Johnson Space Center, Houston, Texas

A mechanical shock absorber keeps its frictional damping force within a tolerable limit. Unlike in other mechanical shock absorbers, its damping force does not increase with the coefficient of friction between its energy-absorbing components; rather, the frictional damping force varies only slightly—typically by 15 percent at most—as the coefficient of friction increases beyond a typical threshold value of about 0.1.

This shock absorber is relatively insensitive to manufacturing variations and environmental conditions that alter friction. Moreover, unlike some other mechanical shock absorbers, it does not exhibit high breakaway friction and the consequent sharp increase followed by a sharp decrease in damping force at the beginning of stroking. Also, unlike in hydraulic shock absorbers, the damping force in this shock absorber does not vary appreciably with speed of stroking. Of course, in addition, it is not vulnerable to leakage of hydraulic fluid.

The shock absorber (see figure) includes a main housing with a threaded



Frictional Diaphragm Elements are tilted when the shaft is at rest. They are driven more nearly perpendicular to the shaft during stroking. Under excessive applied stroking load, they tilt in the opposite direction, reducing the frictional damping force.

section that mates with the moving body to be stopped. The stroking component is a shaft that extends from the housing. A tip at the outer end of the shaft makes contact with a stationary hard stop. A retaining ring holds the shaft in the main housing. A spring in another housing is fastened to the opposite end of the main housing. The spring returns the shaft to its original position after stroking.

Frictional diaphragm elements held in the main housing rub on the shaft to dissipate energy. A Belleville spring helps to regulate the damping force. These components function together as follows: When the shaft is at rest, the frictional diaphragm elements remain tilted as shown in the lower left part of the figure. When the shaft strokes, these elements are forced to become more nearly perpendicular to the shaft, thereby squeezing the shaft and exerting the frictional damping force. As these elements are deflected from the static tilted configuration, they come into contact with the Belleville spring. As the frictional force continues to grow, the Belleville spring resists the further deflection of these elements, thereby helping to limit the squeezing and frictional forces. If these elements become deflected beyond perpendicularity toward a tilt opposite that of the static condition, then further tilting results in a decrease of frictional force. Thus, the shock absorber regulates itself, regardless of the coefficient of friction.

Each frictional diaphragm element contains three tabs that ride on the shaft. The tabs are joined by tension beams. The inner diameter of each such element is made slightly smaller than the outer diameter of the shaft, so that they tend to remain tilted at rest and to squeeze the shaft increasingly as they are forced toward perpendicularity to the shaft. The tension beams accommodate the displacement of the tabs during stroking.

This work was done by Clarence J. Wesselski of Lockheed Engineering & Sciences Co. for **Johnson Space Center**. *For further information,* ***write in 103*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22111.

Portable Device Measures Perpendicularity of Threaded Hole

Measurements can be made easily in factory, shop, or field.

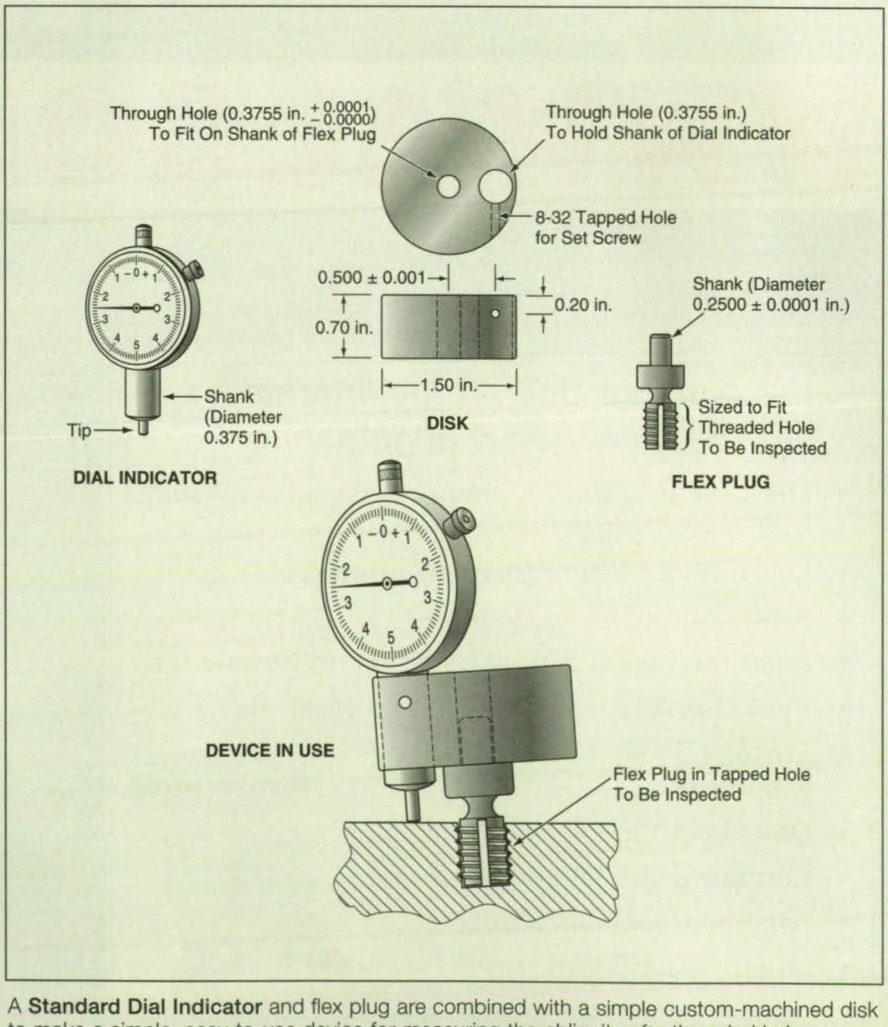
Lewis Research Center, Cleveland, Ohio

A simple portable device gives quantitative information on the amount by which the axis of a threaded hole in a workpiece deviates from perpendicularity to the adjacent exterior surface of the workpiece. The device can be used in place of more cumbersome inspection equipment like surface plates, optical comparators, and coordinate-measuring machines, all of which require elaborate setup and are unsuited to use in the field. Inasmuch as neither elaborate additional equipment nor elaborate setup is necessary to use this device, it is well suited for measurements in the field as well as in the shop or laboratory.

The device is an assembly of three relatively inexpensive components (see figure):

- A commercial dial-indicator linear-travel gauge that has a shank of 0.375-in. (9.525-mm) diameter, a total travel of about 1.00 in. (25.4 mm), and scale increments of 0.0005 in. (0.0127 mm);
- A commercial centerline flex plug, chosen to match the size and thread of the hole to be inspected; and
- A disk made of bearing bronze, custom-machined with a central axial hole that mates with the plug, an outer axial hole that fits the shank of the dial indicator, and a hole tapped for a set screw that holds the dial indicator in place.

Use of the device begins with screwing the flex plug into the threaded hole to



A **Standard Dial Indicator** and flex plug are combined with a simple custom-machined disk to make a simple, easy-to-use device for measuring the obliquity of a threaded hole.

be inspected. Next, the disk is placed on the flex plug so that its central axial hole engages the shank of the flex plug. The disk is thereby centered on, and oriented perpendicular to, the threaded hole to be inspected. The dial indicator is inserted in the 0.3755-in. (9.5377-mm) outer axial hole in the disk so that its tip makes contact with the workpiece and indicates displacement of 0.030 in. (0.762 mm). The set screw is lightly tightened to hold the shank of the dial indicator in place, and the dial is set to zero.

The disk is then turned, so that the contact point at the tip of the dial indicator traces out a circle around the hole to be inspected. During this procedure the dial indicator is observed for any deflection from the zero point position. Any deflection in the dial indicator from the zero point gives the amount of deviation from perpendicular in units of 1.000 in. (25.4 mm). In order to calculate the amount of deviation for a specific depth, the formula is as follows: If the total indicator reading is 0.0045 in. (0.1143 mm), and the feature tolerance is 0.003 in. (0.076 mm) at 0.375 in. (9.525 mm) of depth, the threaded hole is out of perpendicular 0.0016 in. (0.0406 mm) in 3/8 of an inch (9.525 mm). The calculation would be 0.0045 (total indicator reading) × 0.375 (length of feature) = 0.0016875 (deviation from perpendicular).

This work was done by August R. Scarpelli and Daniel W. Buttler of **Lewis Research Center**. *For further information,* ***write in 168*** *on the TSP Request Card. LEW-15444*

Preload-Release Mechanism for Mounting Electronics Boxes

The mechanism would maintain preload only briefly.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed mechanism would apply a spring preload to an electrical connector only while it was needed — during insertion of an electronics box into a supporting frame. Once the connector was fully mated, the mechanism would relieve the preload. As a result, the supporting structure could be sized to handle only the individual load applied briefly by each connector on the box during insertion.

In electronic-equipment racks of the "blind-mate" design, spring forces are applied to the supporting structure as long as the boxes remain installed, even though preload is not needed once the connectors are fully engaged. The preload forces can be large, especially due to the dimensional tolerances in the boxes which the compression springs must be designed to accommodate. The force per spring can easily reach 85 lb (378 N), with as many as eight springs required for a large connector.

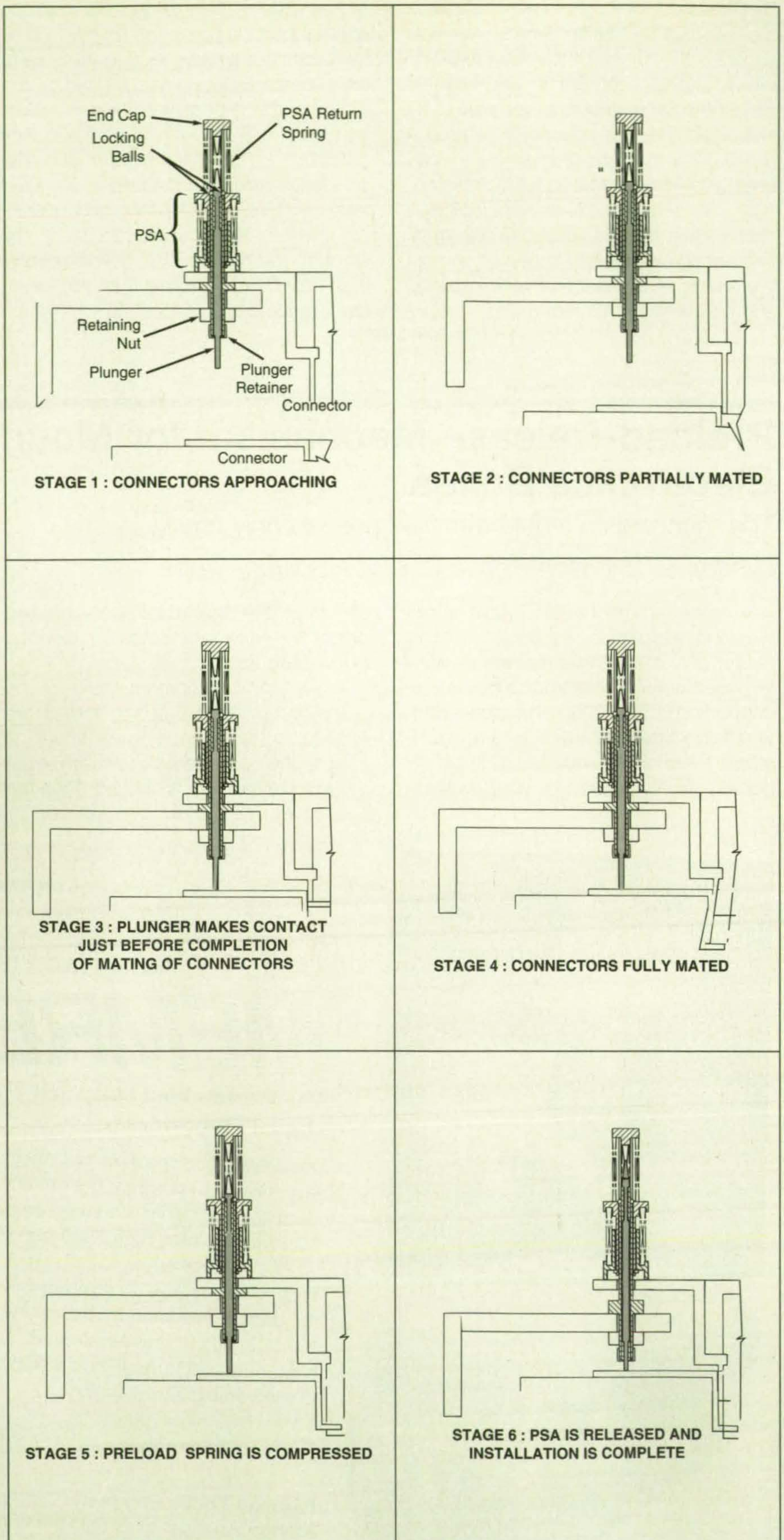
The supporting structure must withstand the combined force of the springs in all connectors. Therefore, the structure must be stiffer, stronger, and heavier than it would have to be if the preload were removed once a box was installed.

In the proposed mechanism, the preload would be applied to a connector by a spring captured by a pair of bushings in a preload spring assembly (PSA). The PSA would slide on a shaft that would contain a plunger-operated release mechanism, much like the quick-release ball-lock-pin mechanisms commonly used in aerospace and military equipment.

Before installation of the box, the PSA would be locked in place on the shaft by locking balls (see figure). As the connectors began to mate, the PSA would remain locked, providing support for a connector plate. The external end of the plunger would make contact with the rear surface of the shortest possible electronics box approximately 0.03 to 0.06 in. (0.76 to 1.52 mm) before the connectors become fully engaged. As the box traveled the final 1/8 in. (about 3 mm) to its installed position, the preload spring would become compressed, and the plunger would be depressed. The resulting motion of the plunger would allow the locking balls to drop into the shaft: this would release the PSA, the resulting motion of which would, in turn, release the preload. The only remaining load on the connector support would be the few pounds (of the order of 10 N) provided by the PSA return spring. Boxes that were on the long side of the tolerance range would be accommodated by travel of the PSA beyond the locked position.

This work was done by Robert M. Generoli and Harry J. Young of McDonnell Douglas Corp. for **Johnson Space Center**. *For further information,* ***write in 57*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22327.



This **Sequence of Events** occurs during installation of an electronics box and mating of connectors. The mechanism is designed to accommodate the full dimensional range of manufacturing tolerances for a box of a given nominal size.

Zip Boom

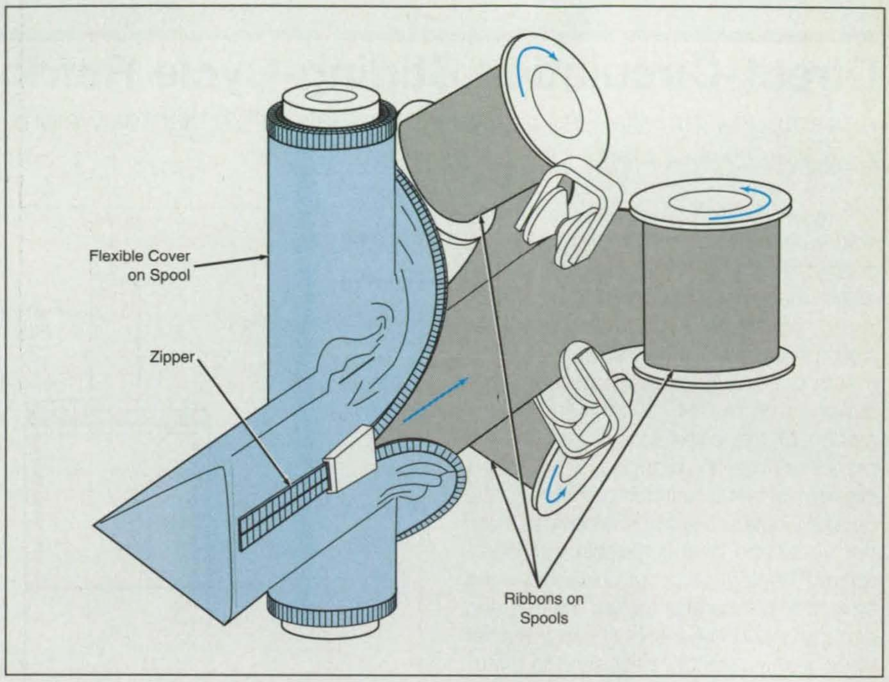
Lightweight deployable structural elements are combined in a stiff geometry.

Lyndon B. Johnson Space Center, Houston, Texas

The zip boom is a lightweight, stiff structural member that can be extended to a great length or retracted into a compact package. It includes three spools of spring-steel ribbon (or other springy ribbon material) arranged so that the ribbons join in a beam of triangular cross section as they unfurl from the rotating spools (see figure). A zippered case extends with the beam, along with a slider that continuously closes the zipper to keep the three extended ribbons wrapped. The tightly fitting case ensures that the edges of the three ribbons always abut each other, without overlapping or slipping. The ribbons thus act as a unit with a triangular cross section that ensures great stiffness.

Each ribbon has to flex around only one axis — that of its spool. Therefore, the ribbon can be made thick, further increasing the stiffness of the boom.

This work was done by Scott Swan of **Johnson Space Center** *and Richard Smallcombe of ILC Space Systems. For further information,* ***write in 104*** *on the TSP Request Card. MSC-22262*



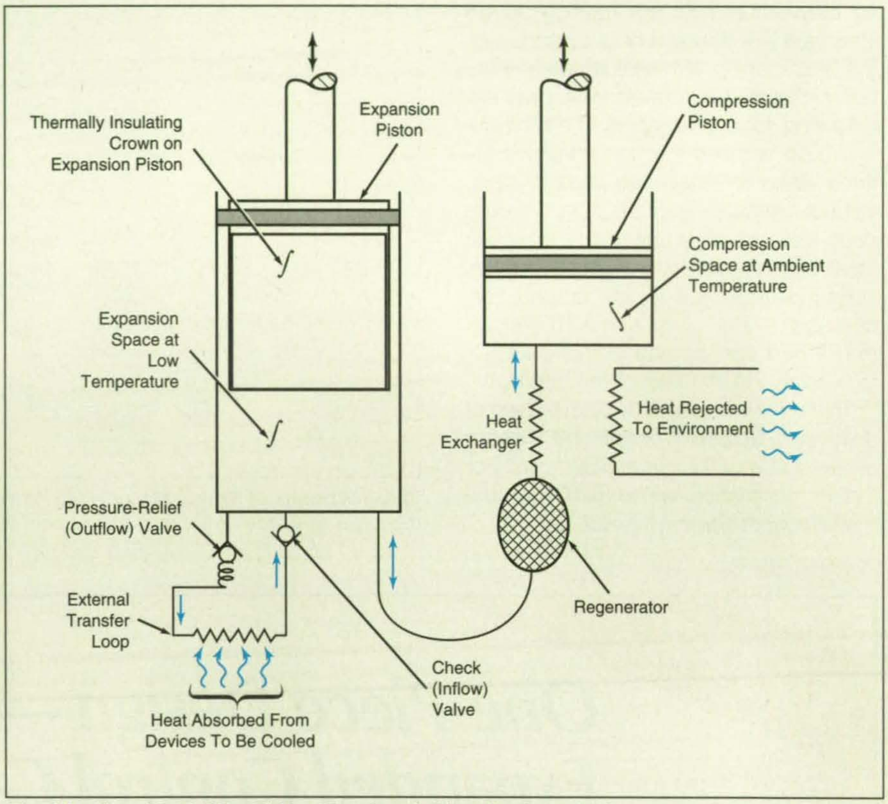
Three Ribbons of Spring Material are joined at their edges to form a triangular boom. A flexible case zips around the extending boom to keep it triangular.

Direct-Circulation Stirling-Cycle Refrigerator

Advantages include less complexity, smaller size, lighter weight, and lower power consumption.

Marshall Space Flight Center, Alabama

In a proposed cryogenic system, the cold working fluid (helium) would be circulated directly from Stirling-cycle refrigerator machinery through a loop of tubing to provide 15 W of cooling power at a temperature of 80 K to scientific instruments or other devices located at some distance from the machinery. (Separation of the cooled devices from the machinery may be dictated by engineering requirements including, notably, the need to isolate the cooled devices from the vibrations of the machinery.) Heretofore, the separation of cooled devices from the refrigerator would have been accomplished by use of (1) an intermediate heat exchanger between the refrigerator and an external transfer loop plus (2) an additional pump to circulate cryogenic fluid within the external cooling transfer loop. In comparison with older Stirling-cycle refrigerators of equal cooling power, the proposed refrigerator would have to be designed oversized with respect to volumetric displacement to provide for direct external circulation of the working fluid. However, the increase in size should be more than offset by the reductions in the number of components, size, weight, and power consumption that would be afforded by elimination of the intermediate heat exchanger and external coolant pump.



The **Working Fluid Would Be Circulated Directly** through the external transfer loop by exploiting the pressure cycle in the Stirling working space (the expansion and compression spaces and the plumbing between them).

In the ideal Stirling refrigeration cycle, the working fluid takes on heat at constant volume as it passes through a regenerator from a cold expansion space to a warm compression space (at ambient temperature in this case). The regenerator acts as a thermodynamic analog of a sponge, cyclically absorbing heat from and releasing heat back to the working fluid. Heat is rejected from the system through a heat exchanger during an isothermal compression in the compression space. The working fluid then passes back through the regenerator in a constant-volume regenerative cooling process. Heat is stored in the regenerator for transport out in the next cycle. Finally, refrigeration occurs in an isothermal expansion process in the expansion space, where heat is absorbed by the working fluid. The ideal Stirling cycle has the same theoretical thermodynamic performance as does the Carnot cycle. Both ideal cycles are impossible to achieve in practice. Practical Stirling refrigerators can achieve up to 40 percent of the ideal Carnot performance.

In the proposed system (see figure), an expansion piston and a compression piston would reciprocate in parallel cylinders, synchronously but with the expansion piston about 90° ahead in phase. The working fluid would therefore shuttle through the regenerator between the compression and expansion spaces, and the total volume available to the working fluid would also vary cyclically. Compression would occur when the working fluid was mostly in the compression space. Similarly, expansion would occur when the working fluid was mostly in the expansion space.

A portion of the Stirling pressure cycle would be used to pump the cold working fluid between the expansion space and the external transfer loop: this would be a new operating mode for a Stirling machine. Ingress and egress of the working fluid would be accomplished by spring-loaded, pressure-regulating valves that would operate automatically as the pressure in the working fluid varied cyclically; the effect on the pressure cycle would be to clip the pressure peak somewhat. At the beginning of a cycle, both valves would be closed, and pressure would be increasing. After the pressure reached a preset relief setting, a pressure-actuated outflow valve would open, allowing working fluid to flow into the external loop, which would be maintained at the minimum cycle pressure. The outflow would continue until the volume in the Stirling working space reached its min-

imum, and then both valves would close.

As the cycle continued, the volume in the Stirling working space would increase, causing refrigeration by expansion. The pressure in the Stirling working space would decrease during this expansion until it became equal to the pressure in the external coolant loop. Further increase in volume would cause working fluid in the external transfer loop to flow through a check valve back into the expansion space, carrying with it the heat that it had absorbed from the devices to be cooled.

This work was done by Woody Ellison and Randall Kohuth, Sr., of General Pneumatics Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 41*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26244.

Stepping-Motor Drive Suppresses Torsional Oscillation

Steps are equal and paired at half the period of torsional oscillation.

Goddard Space Flight Center, Greenbelt, Maryland

Figure 1 illustrates a stepping-motor drive that rotates an antenna, solar photovoltaic array, or similar flexible structure to a commanded angle. The amplitude and timing of the rotational steps of the stepping motor can be controlled in such a way as to suppress the torsional oscillations excited in the structure by these steps.

The top part of Figure 2 shows what happens when the rotational step excitations are applied in a conventional manner; namely, as single steps at intervals of T. (T is a time chosen consistent with the commanded rate of rotation and is typically much greater than the period of torsional oscillation.) In the absence of damping, each step excitation contributes to the amplitude of torsional oscillation; this effect can be especially pronounced if T is an integral multiple of the oscillation period.

The excitation in this stepping-motor drive differs from the conventional excitation in that each step is divided into two equal smaller steps separated by a small interval, τ. This interval is chosen to equal half the period of torsional oscillation, so that the second step excitation is equal in amplitude but opposite in phase to the first step excitation. Thus, although the first step unavoidably excites a torsional oscillation, the second step deexcites the oscillation at the end of its first half cycle (see Figure 2). The interval τ can be preset, or else the command unit in the stepping-motor drive can be designed to measure residual torsional oscillations repeatedly to update τ when the torsional oscillatory characteristics are subject to change.

This work was done by Mahabaleshwar K. P. Bhat of Ford Aerospace and Communications Corp. for **Goddard Space Flight Center**. *For further information,* ***write in 63*** *on the TSP Request Card.*
GSC-13100

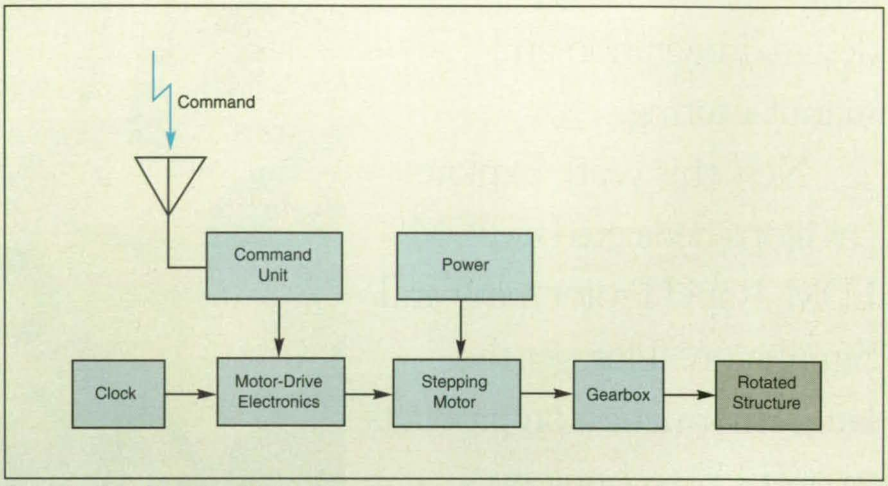


Figure 1. This **Stepping-Motor Drive** implements a paired-step excitation scheme in which the steps in each pair apply equal rotational excitations at opposite phases of the torsional oscillation.

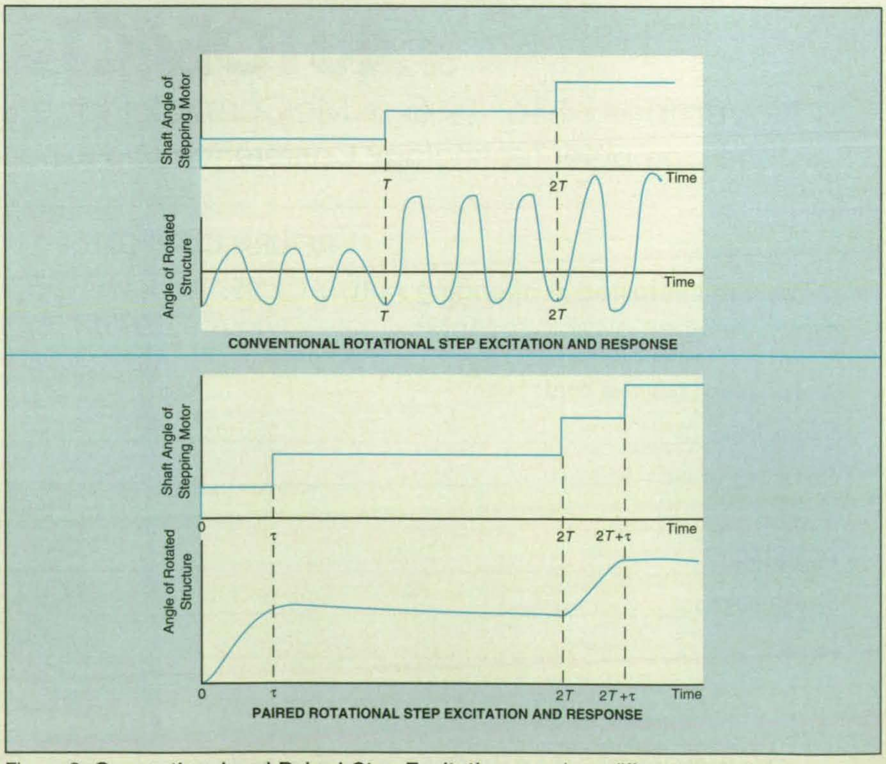


Figure 2. **Conventional and Paired-Step Excitations** produce different responses.

Automated Positioner for a Specimen in a Vacuum Chamber

This apparatus is made from relatively inexpensive parts.

Lewis Research Center, Cleveland, Ohio

A custom-built apparatus positions a specimen in a vacuum system in three translational and one rotational degree of freedom. The apparatus operates under manual control, local microprocessor control, or remote computer control via a general-purpose interface bus (GPIB), the specific control option being selectable by the technician. It is used, for example, to position and orient a specimen for secondary-ion mass spectroscopy (SIMS). The cost of parts to construct the system (excluding the computer and a specimen manipulator) was $800 in 1991 — less than one tenth the cost of a general-purpose commercial vacuum manipulator system at that time.

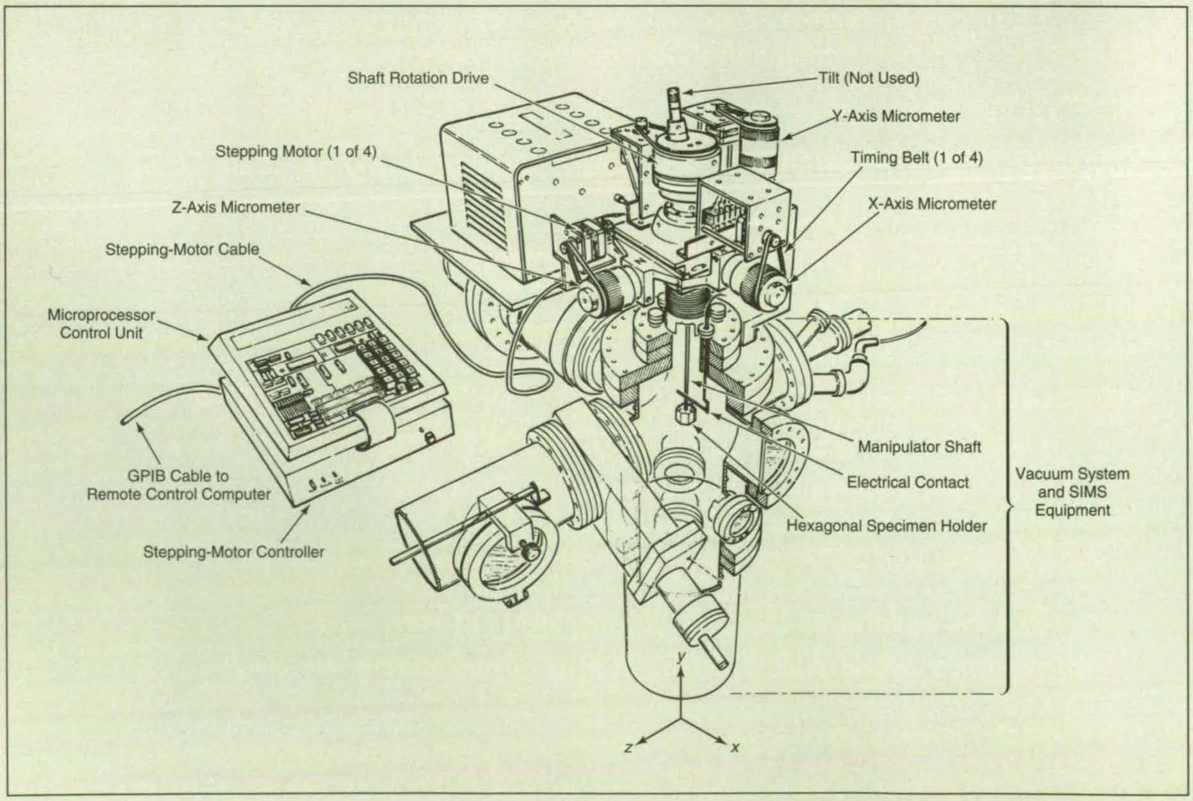
The apparatus includes a separate stepping motor to generate movement in each of the four degrees of freedom. The stepping motor for each translational degree of freedom drives a micrometer stage. The stepping motors are compact biphase motors with 100 steps per revolution. Their positional and step-to-step accuracy is +5 percent. Timing belts and matching pulleys increase both the precision and the torque available to drive the micrometer stages for the translational degrees of freedom. A pulley drive with a ratio of 3.6:1 is used for the rotational degree of freedom. The net resolutions are 1 μm per step in translation and 1° per step in rotation. For simplicity, no switches, optical encoders, or similar hardware for absolute positioning is included. Therefore, it is necessary to give the computer program the initial coordinate settings at start-up.

The microprocessor control unit is based on the 8-bit Motorola MC6802 microprocessor. It includes a 17-key keyboard and a 6-digit, seven-segment light-emitting-diode (LED) display for standard input and output operations. It contains 2.5 Kbytes of random-access and read-only memory.

The software for both the local and remote modes of computer control is about 2 Kbytes long and resides in the read-only memory. When the technician initiates operation by pressing a "run" button switch on a controller box, the software initializes the settings of a data-communication interface circuit, displays the GPIB address of the microprocessor unit, assigns specific control functions to the keys on the keyboard, and displays the present value of the angular coordinate. The technician can then provide input from the keyboard, or the remote control computer can supply input in the form of previously defined bus commands.

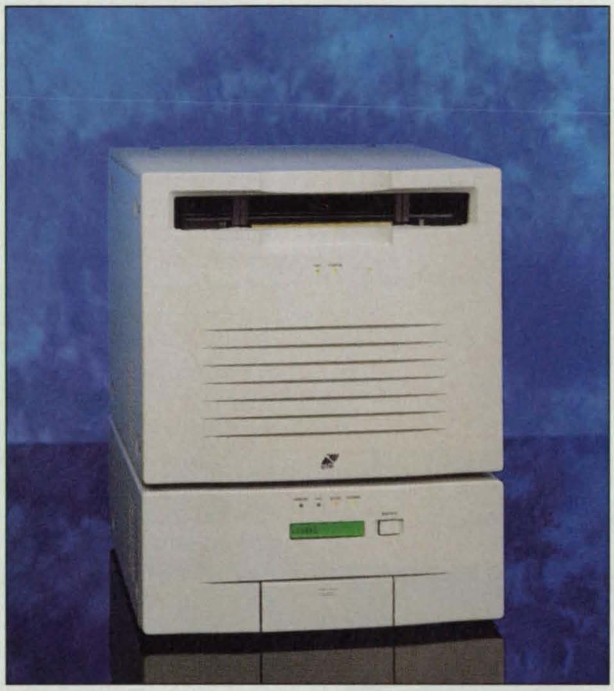
The repeatability of positioning achievable by the apparatus was measured in an experiment in which a silicon specimen was bombarded with a 0.250-μm-wide beam of oxygen ions in one spot, then the apparatus was used to move the specimen in a pattern, stopping along the way to bombard the specimen similarly in other spots. The pattern was chosen in such a way as to produce, then remove backlash in two of the three degrees of translational freedom. At the end, the specimen was returned to its original nominal position and bombarded again. The second bombardment crater at the original position was collocated with the first; the only difference was that the crater became larger in the second bombardment.

This work was done by Sheila G. Bailey of **Lewis Research Center** *and Carlos Vargas-Aburto and Dale R. Liff of Kent State University. For further information,* ***write in 24*** *on the TSP Request Card. LEW-15904*



The **Vacuum-Chamber Specimen Positioner** contains four stepping motors — one for a rotational degree of freedom and one for each of three translational degrees of freedom.

42 GB at 12 MB Per Second.



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Brake Stops Both Rotation and Translation

A single actuator energizes both braking actions.

Langley Research Center, Hampton, Virginia

A combination of braking and positioning mechanisms allows both rotation and translation before the brake is engaged. These mechanisms are designed for use in positioning a model airplane in a wind tunnel. A modified version could be used to position a camera on a tripod.

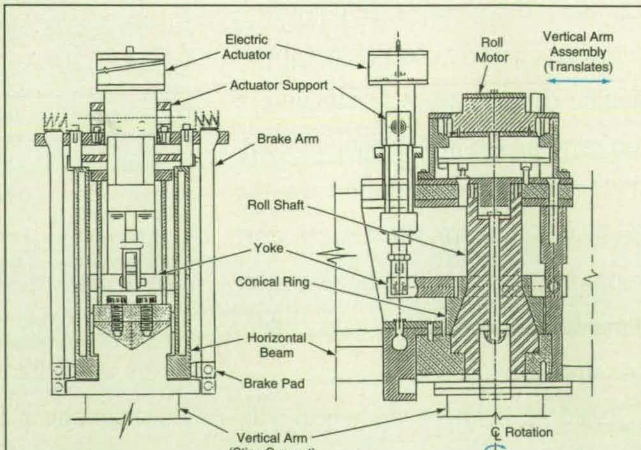
The brake is fast and convenient to use; It contains a single actuator that energizes the braking actions against both rotation and translation. The braking actuator is electric, but a pneumatic actuator could be used instead. The brake is compact and lightweight, applies locking forces close to the load, and presents minimal cross section to airflow.

The combination of braking and positioning mechanisms includes a vertical arm that is held up by a horizontal arm. The vertical arm holds a rod (called a "sting" in the wind-tunnel industry) on which the model is mounted. When the brake is not engaged, the vertical arm can translate along the horizontal arm and can rotate. An electric motor that is part of the positioning mechanism rotates the vertical arm to position the model as required.

When the required position has been reached, the brake is engaged: the brake actuator pushes downward on a yoke, forcing a conical ring onto a tapered portion of a roll shaft, thereby imposing friction against rotation. The reaction force from the engagement of the ring and roll shaft pushes the actuator upward, pressing serrated brake pads into contact with serrations on the horizontal arm, thereby locking against translation. Until deliberately disengaged, the brake remains engaged, even during a power failure.

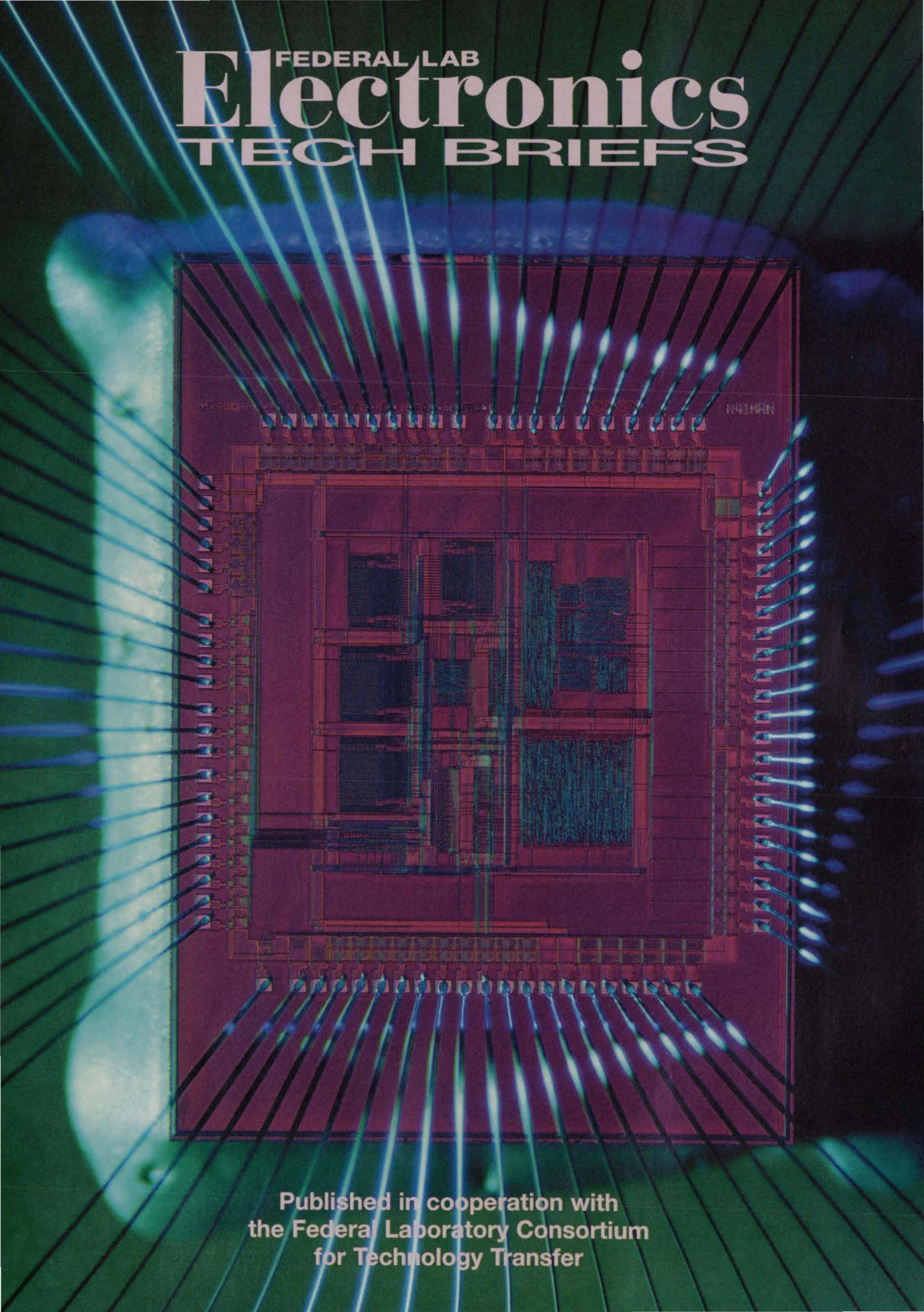
This work was done by Johnny W. Allred and Vincent J. Fleck, Jr., of **Langley Research Center**. *For further information,* ***write in 34*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-14738.



The **Single Motion of the Actuator** presses the conical ring against the conically tapered section of the roll shaft. This action simultaneously stops both translation of the mechanism along the horizontal arm and rotation of the vertical arm.

Federal Lab Electronics Tech Briefs



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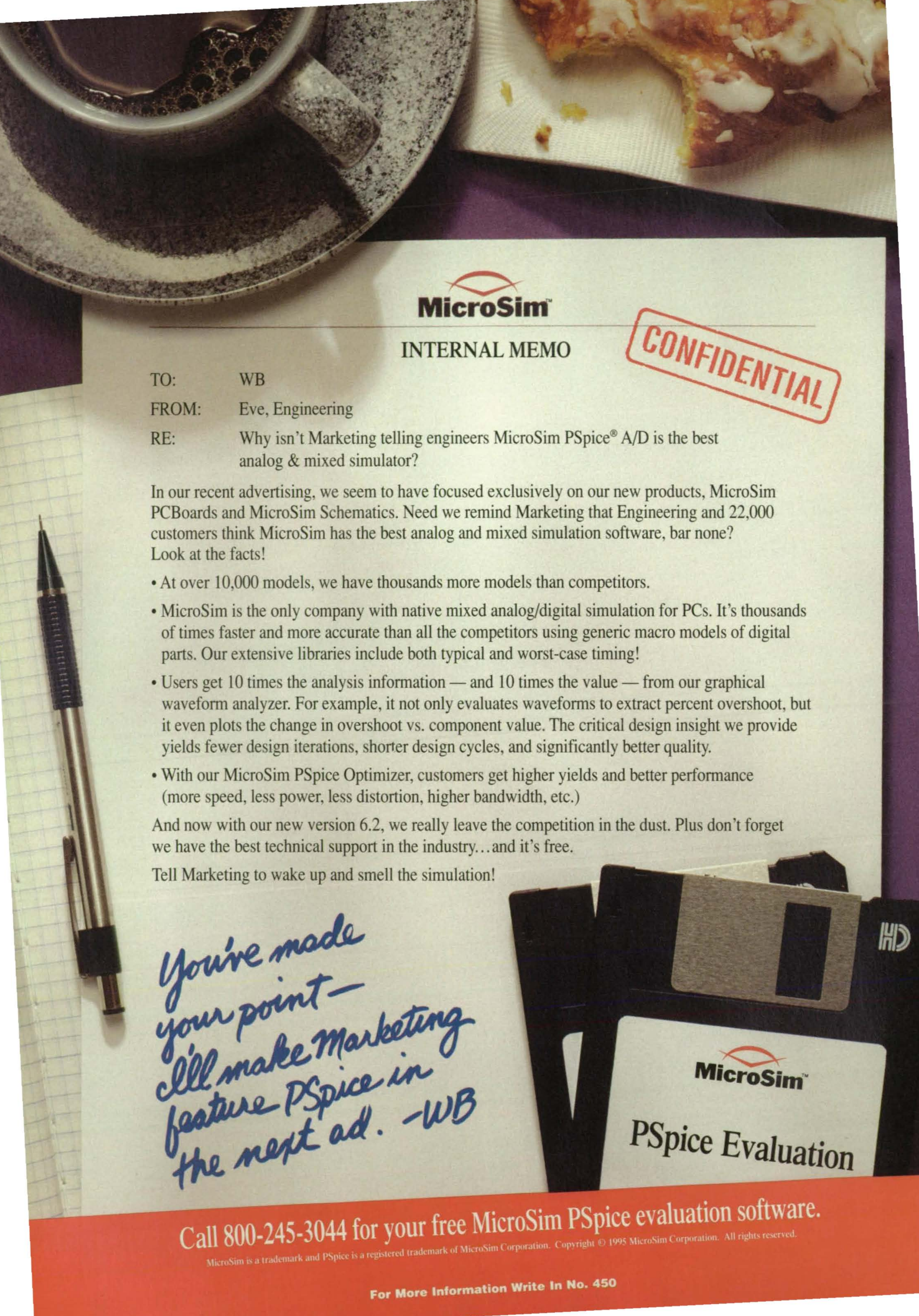
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CONTENTS

Federal Lab Electronics Tech Briefs
Supplement to *NASA Tech Briefs* September 1995 Issue
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ELECTRONICS TECH BRIEFS

On the cover

The pictured stream memory controller integrated circuit was designed and fabricated by the Center for Semicustom Integrated Systems (CSIS) at the School of Engineering and Applied Science of the University of Virginia, using the facilities of the ARPA/MOSIS program. Photo courtesy of CSIS.

EDITORIAL NOTEBOOK

News of the Federal Laboratories and Industry

• Space Imaging (Thornton, CO) and Lockheed Martin Missiles & Space (Sunnyvale, CA) announced in mid-July that Eastman Kodak (Rochester, NY) was chosen to supply the digital camera for Space Imaging's commercial remote-sensing satellite (CRSS), scheduled for launch in 1997. The satellite is expected to bring Earth imagery of the highest resolution available to commercial customers worldwide. After Space Imaging and prime contractor Missiles & Space completed the preliminary design review of CRSS in June, the companies made public the selection of Kodak to provide an integrated imaging payload that represents a tenfold increase in existing image resolution quality.

The digital camera comprises a Kodak-designed and manufactured focal plane array and a lightweight telescope using a state-of-the-art mirror fabricated with Kodak's advanced ion figuring technology. Downloading of data to Space Imaging's ground stations will be speeded by Kodak's proprietary bandwidth compression technology.

• A cooperative research and development agreement (CRADA) among a company based in San Diego, a Midwest federal research center, and former Soviet weapons scientists has resulted in a method for tracing the flow of current through high-temperature superconductors. The 2-1/2-year, $500,000 research project brought together Phase Metrics, the Department of Energy's Argonne National Laboratory (Argonne, IL), and scientists from the Institute of Solid-State Physics (ISSP) from outside Moscow. Using a technique called magneto-optical flux imaging, the team pinpointed tiny particles in the superconducting wires that impede current flow. Key to the process is an indicator film invented by the former Soviet scientists.

• The machine vision supplier Cognex Corp. (Natick, MA) has signed an agreement to acquire Acumen Inc. (Portland, OR), a developer of machine vision systems that read the increasingly complex semiconductor wafer identification codes. The acquisition brings Cognex the ability to read barcodes and user-defined fonts in addition to the industry-standard SEMI font.

• The Defense Technical Information Center (DTIC) announced the Defense Technical Information Web (DTIW), a starting point for accessing Department of Defense information such as DefenseLINK, DoD directives and instructions, LABLINK, Air ForceLINK, and the White House. To access DTIW, URL to: http://www.dtic.dla.mil/dtiw/.

• The US Geological Survey (USGS) and Sprint Corporation entered into a cooperative research and development agreement (CRADA) to utilize advanced, high-speed wide-area networks in innovative ways. The CRADA, a three-phase, three-year effort that will include hardware and software as well as an asynchronous-transfer-mode network link, will support USGS's development of a prototype for the remote archiving, access, and delivery of large (1+ gigabyte) image data sets. For more information, contact David Terrell, USGS EROS Data Center, Sioux Falls, SD 57198; (605) 594-6161; E-mail: DTerrell@usgs.gov.

This column was prepared with the assistance of the Federal Laboratory Consortium for Technology Transfer. Established in 1974 to promote the transfer of federal R&D capabilities into the private sector and state and local governments, the FLC consists of more than 600 member laboratories and research centers from 16 federal departments and agencies. For further information, phone the FLC Management Support Office; (206) 683-1005.

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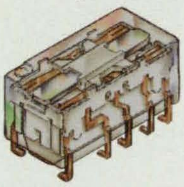
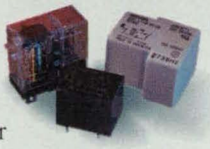


This new third generation, G6S SMT relay has long, bent lead sets mounted on the sides to transfer more heat and provide shock absorption to protect the solder joints.



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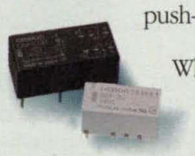

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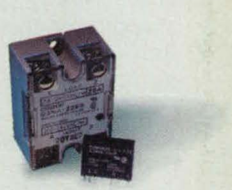

[Solid State]

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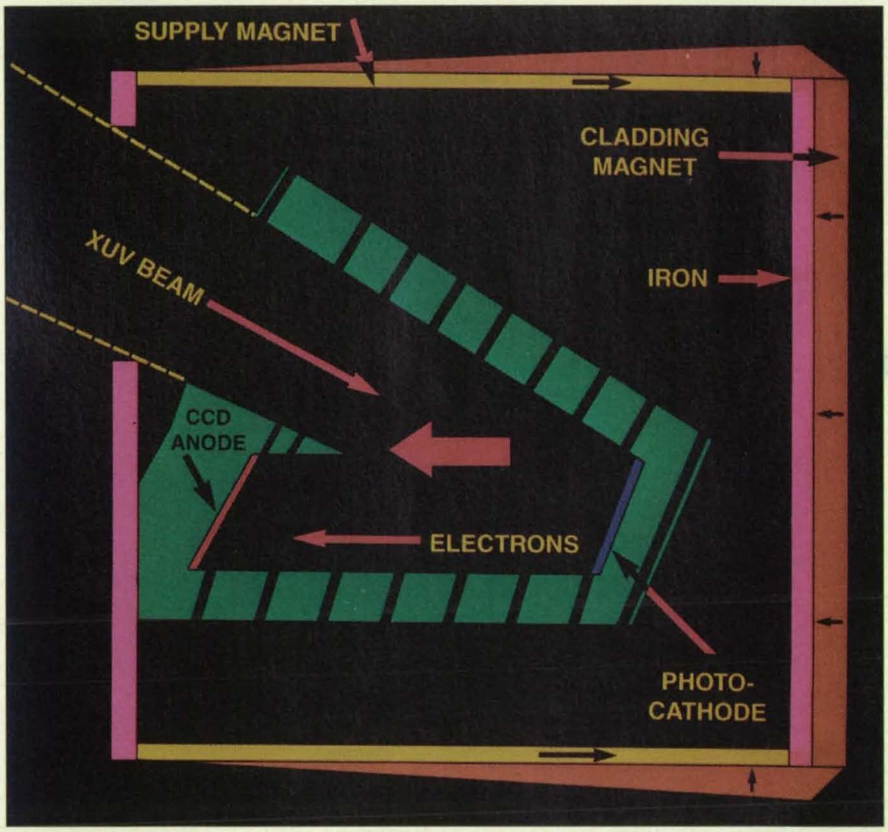
Permanent Magnet Circuit Design

Innovative circuits provide solutions for a wide range of electron-beam focusing and electromechanical applications.

Physical Sciences Directorate, Army Research Laboratory, Fort Monmouth, New Jersey

The Army Research Laboratory is continuously asked to reduce the size, complexity, weight, and power consumption of a wide variety of electronics and electromechanical systems utilized in countless military and dual-use systems such as MRI magnetic field systems, x-ray/UV imagers, magnetic ore separators, motors/generators, and others. By experimenting with complex magnet shapes, researchers found that very small rare-earth permanent magnets could completely contain and concentrate the magnetic field in a single location, thereby producing fields with strengths on the order of those obtained with electromagnets without cooling or the need for high-current power supplies.

Building a magnetic design center around this concept, ARL created a unique facility in which computer assisted 3D finite element analysis was coupled with sophisticated evaluation instrumentation and an experienced multidisciplinary staff to conceive, design, analyze, and test magnet field strengths and uniformities. Using the design concepts learned, ARL designed permanent magnet electron-beam focusing devices with the high fields necessary for special military applications, such as the CORPSAM family of missiles.



A **Permanent Magnet Circuit** designed for electron-beam guidance. The device shown is for a spaceborne x-ray/UV imager. Large arrow is magnetic field direction; small arrows are magnetic material orientations.

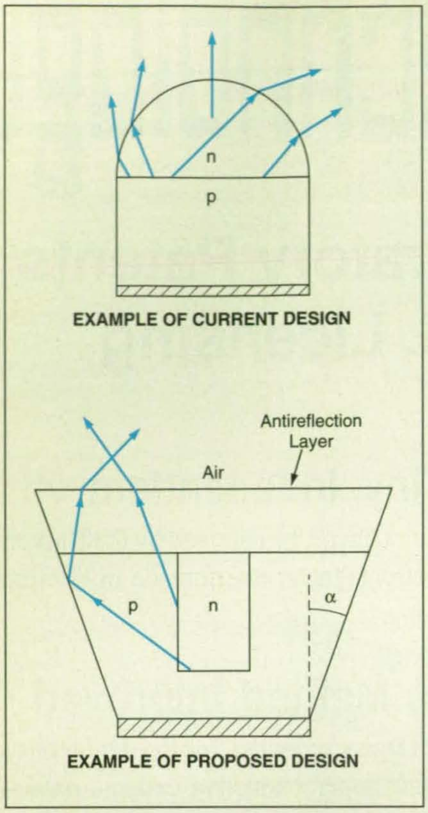
This work was done at the Physics Division, **Physical Sciences Directorate, Army Research Laboratory,** *Ft. Monmouth, New Jersey 07703. For further information, contact Dr. Ernest Potenziani II at ARL, Physics Division, Physical Sciences Directorate, AMSRL-PS-PC, Ft. Monmouth, NJ 07703; (908) 427-3628; Internet address: epotenziani@ftmon.arl.mil.*

Reshaping Light-Emitting Diodes To Increase External Efficiency

Rays would be redirected to reduce trapping by total internal reflection.

Langley Research Center, Hampton, Virginia

Light-emitting diodes (LEDs) would be reshaped, according to a proposal, to increase the amount of light emitted by decreasing the fraction of light trapped via total internal reflection. Because the reshaping would utilize light that is generated in any event but is lost by trapping in present LEDs, the reshaping would result in greater luminous output power for the same electrical input power; in short, greater external efficiency. Furthermore, the light emitted by the reshaped LEDs would be more nearly collimated (less diffuse) than is the light from older LEDs.



The **Conical Side Wall** of the proposed design would reduce trapping, as does the hemisphere in the current design, but the proposed design would be easier to implement and would concentrate more light in the forward direction.

Total internal reflection is a function of the geometry and indices of refraction of the component materials of the LED. The range of angles of incidence in which total internal reflection occurs increases with the indices of refraction. Most semiconductors exhibit high indices of refraction (in general, 3 or more), so that trapping by total internal reflection can be particularly severe in these materials.

One of the older ways to reduce trapping is to shape the semiconductor/air interface into a hemisphere, as shown in the top part of the figure. This approach is disadvantageous in that the hemisphere diffuses the light, thereby decreasing the intensity of emission in any given direction. It is also difficult and expensive to shape semiconducting material into a hemisphere.

The bottom part of the figure illustrates one of several proposed LED shapes that could reduce trapping. The external side surface would be conical. The cone angle, α, would be chosen so that most of the light incident on the conical surface would be redirected in such a way to avoid total internal reflection at the top of the LED (upper part of figure).

The value of α, or the range of acceptable values of α, would be calculated from the applicable equations of geometric optics, using the indices of refraction and geometric parameters of the LED materials. Theoretical geometrical-optics calculations have shown that it should be possible to choose a value of α to untrap all of the light that would otherwise be trapped. To increase efficiency even more, one could reduce Fresnel reflection losses at the front face by covering the front face with an antireflection layer of transparent material that has an index of refraction lower than the indices of refraction of the LED materials.

This reshaping concept is potentially advantageous for conventional red-emitting LEDs. It is even more advantageous — even critical — for the new "blue" LEDs, because the luminous outputs and efficiencies of these devices are very low. Yet another advantage is that the proposed conical shapes could be achieved relatively easily by chemical etching of semiconductor surfaces.

This work was done by Robert Rogowski of **Langley Research Center** *and Claudio Egalon of Analytical Services and Materials, Inc. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-15184.

Ultralow-Background Alpha-Particle Sensor Screens Components

Knowledge gained in neutrino research and sensor design can aid commercial applications of microelectronics.

Physics Division, Los Alamos National Laboratory (LANL), Los Alamos, New Mexico

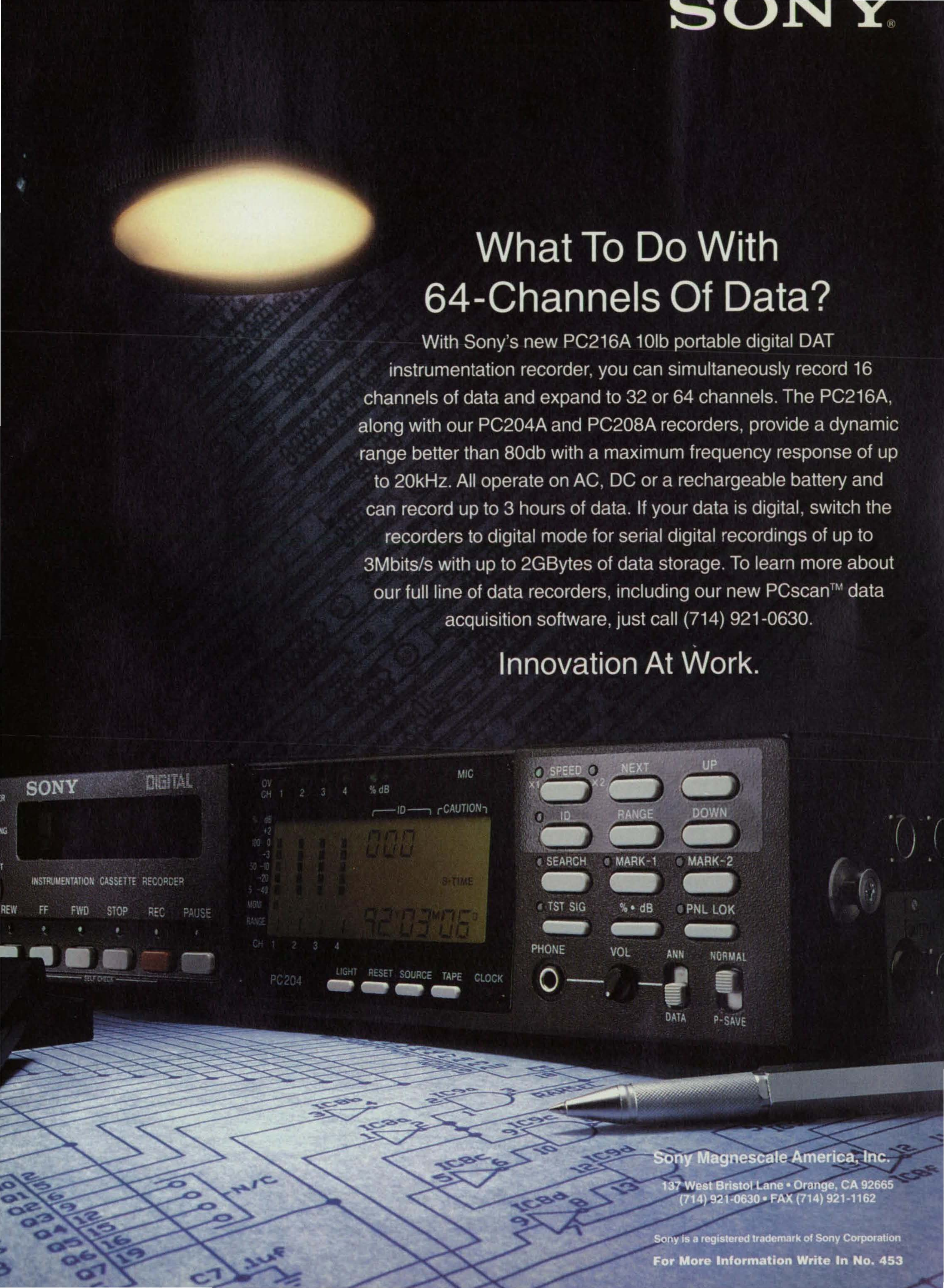
The components for microelectronics are often characterized in terms of "feature size" of the structures embedded in a computer microchip. The microcircuits currently being produced have a feature size in the 0.5-μm range; future microcircuits will be even smaller. The quantity of the electronic charge, or "critical charge," which is used to represent a single bit (0 or 1) in binary code, has significantly decreased with feature size: microelectronics technology has advanced to the degree that a bit is represented by between 100,000 and 10 million electrons in the microcircuit structure.

The tiny amounts of charge can be swamped by the ionization produced by a single alpha particle passing through the circuit element, a phenomenon called a single-event upset (SEU). This problem is further compounded by the fact that naturally occurring alpha particles are emitted from the raw materials of the microchip. For example, the solder used to attach the microchip to connecting leads for the package require lead and tin. The alpha particles emitted from the isotopes of these elements can cause unacceptably high SEU rates in the components of the microchips. Because these naturally occurring isotopes are at very small concentrations and are often chemically similar to the stable elements, refining the raw materials to remove the offending isotopes is difficult.

Lead ore has parts-per-million concentrations of natural uranium, which decays along a chain that results in the long-lived isotope ^{210}Pb. This isotope of lead beta decays to ^{206}Po, emitting a high-energy alpha particle. The uranium and other contaminants are largely removed when the lead is smelted, but ^{210}Pb remains and has definitely been identified as one contributor to SEUs in modern chips.

The 22-year half-life of ^{210}Pb can require the use of old smelted lead (400 years or older) in producing such chips. Other materials, such as aluminum, titanium, gold, and nickel, are also required for semiconductor manufacturing and must be screened for natural radioactivity as well. The current state of the art in alpha-particle detectors, however, may not adequately screen microelectronics materials.

Using technology based on the Sudbury Neutrino Observatory (SNO) sensor, Los Alamos physicists are building a prototype alpha-screening system that is compatible with industrial practices and capable of screening and identifying alpha emitters at 10-100 times lower sensitivities than what systems currently in use can achieve. It will be a version of a sensor for measuring the flux



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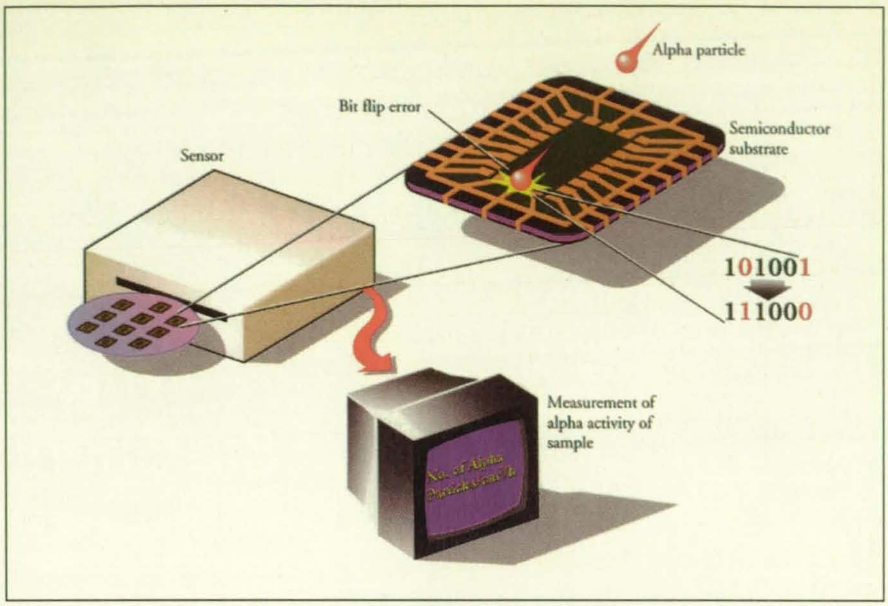
of elusive solar neutrinos from the Sun, modified to measure extremely low-level natural radioactivity in computer microchips. A calibration process has been developed to validate performance.

The modified version of the SNO sensor, being tested at the Waste Isolation Pilot Plant, will quantify how much the isotope concentrations need to be reduced to achieve the desired SEU level. Furthermore, the alpha particle sensor will demonstrate that it can serve the needs of industry by screening material to much lower levels than is currently possible and will do so faster and more accurately than the best currently available sensors.

This work was done at the **Physics Division, Los Alamos National Laboratory**, *Los Alamos, NM. For more information, contact Dr. David Holtkamp, Subatomic Physics Group (P 25), MS D449, LANL, NM 87545; (505) 667-8082.*



Alpha Particles Passing Through a semiconductor substrate can cause bit flips from one binary number to the other (shown in red).

Real-Time Molecular-Beam Epitaxy Flux Inspection Technique

A single-photon ionization time-of-flight mass spectrometric system allows for in-situ monitoring during semiconductor growth.

Joint Institute for Laboratory Astrophysics (JILA), University of Colorado, Boulder, Colorado

A technique for observing the gaseous species present during molecular-beam epitaxy of III-V, II-VI, and silicon semiconductors has been developed, utilizing single-photon laser ionization (SPLI) of gas phase species followed by time-of-flight mass spectrometric (TOF-MS) analysis of the resulting ions. The single-photon ionization probe results in greatly reduced fragmentation of the ions as compared to the more traditional electron-impact ionization sources standard in commercial quadrupole mass spectrometers. The reduced fragmentation greatly simplifies mass spectral interpretation. Additionally, this laser-based probe can interrogate both the species incident to and scattered from the semiconductor's substrate in real time during growth.

The apparatus is housed in an ultrahigh-vacuum chamber equipped with standard surface analysis instruments, including means for observing reflection high-energy electron diffraction (RHEED). This chamber is also equipped with molecular-beam effusive sources of both arsenic and gallium. A five-axis manipulator capable of radiative heating of the substrate positions the growth surface within the extraction region of the TOF-MS. This region is designed to allow unimpeded access of the effusive molecular beams and the RHEED electron beam to the sample, enabling probing of dynamical growth processes.

The laser beam passes near the center of the extraction region, in front—on the molecular-beam side—of, and parallel to, the substrate in a counterpropagating direction to the RHEED beam. The ions generated by the laser beam are then extracted up the flight tube of the TOF-MS and accelerated to a constant energy. The ions impinge on a focused mesh electron multiplier located at the end of the meter-long tube. Ions of different masses are distinguished based on their arrival times at the multiplier, following the ionizing laser pulse. The resulting mass spectra can be examined using a digital oscilloscope, or individual species can be followed in time through a computer interface.

The single-photon ionization probe laser utilizes 118-nm radiation, which provides sufficient energy (10.5 eV) to ionize, but not fragment, most of the species used in semiconductor epitaxy. This radiation is the ninth harmonic of the Nd:YAG laser and can be generated rather easily. The fundamental (1064-nm) output from a commercial Q-switched Nd:YAG laser is tripled to give 355-nm radiation using standard nonlinear optical techniques. The repetition rate of this laser is 10 Hz; an average laser pulse has approximately a 5-ns duration.

The third-harmonic radiation is then focused by a UV-grade fused-silica lens through a fused-silica window into a static gas cell containing a xenon-argon mixture. The 118-nm radiation is generated in this cell by a nonresonant tripling process. An LiF lens located in the cell then focuses the light through an LiF window and into the extraction region of the TOF-MS in the vacuum chamber, where the ionization occurs.

Typically about 35 mJ per pulse of the 355-nm radiation is focused into an approximately 25-percent mixture of xenon in argon at a total pressure of about 3200 Pa (about 24 Torr) in the gas cell, using a lens with a 50-cm focal length. This results in a conversion efficiency of approximately 1×10^{-5}, producing about 200 nJ per pulse of the 118-nm radiation in the extraction region to the TOF-MS. This quantity of ninth harmonic energy is sufficient to ionize and detect background molecules, such as As_4, in our system, at densities of less than 3×10^7 molecules/cm^3.

Species used in semiconductor epitaxy that have been detected thus far using this technique include Si, Ga, In, As_4, As_2, and As. Mass spectra of a molecular beam of As_4 recorded using the single-photon laser ionization time-of-flight technique show a greatly reduced level of fragmentation compared to multiphoton or electron impact ionization. For exam-

ple, the As_3^+, As_2^+, and As^+ signals observed in the As_4 mass spectra obtained using the SPLI TOF-MS method are less than 0.1 percent (noise level), 0.4 percent, and less than 0.1 percent, respectively, of the As_4^+ signal. This can be compared with multiphoton ionization, using a focused beam of approximately 3 mJ per pulse of 266-nm radiation, the fourth harmonic of the Nd:YAG laser, of the same As_4 beam, which resulted in signal levels for the same species of approximately 40 percent (noise level), 415 percent, and 55 percent respectively of the As_4^+ signal.

The scattered and desorbed species present during epitaxial semiconductor growth can also be probed in real time using this technique. For example, by following the evolving arsenic fluxes during GaAs growth, the arsenic uptake can be observed during growth stages by noting the decreases in the As_4^+ and As_2^+ mass spectral signal levels. These uptakes correlate very well with the expected incorporation rates, which are based on the information obtained using the RHEED surface probe.

The SPLI TOF-MS technique's noninvasive probe allows almost continuous detection of the gas phase species present above the wafer's surface during the deposition process. The technique is capable of simultaneous measurement of multiple species in real time, thus permitting possible feedback control of source fluxes. It can be utilized in situations where more traditional probes, such as RHEED, are not as useful, such as growth at high temperatures or growth on a rapidly rotating substrate. Work is currently in progress to extend the technique to use as a probe in dry-etch processes for silicon and in silicon molecular-beam epitaxy.

This work was done by Adina K. Kunz, April L. Alstrin, and Russell V. Smilgys (currently with Surface Applications International Corp.) of the University of Colorado and Sean M. Casey, Paul G. Strupp (currently with Rocky Mountain Magnetics), and Stephen R. Leone of the National Institute of Standards and Technology for the **Joint Institute for Laboratory Astrophysics**.

Inquiries concerning rights for the commercial use of this invention should be addressed to Marcia Salkeld, Technology Development Program, National Institute of Standards and Technology, Bldg. 221, Rm. B-256, Gaithersburg, MD 20899; (301) 975-3111, ext. 4188; FAX (301) 869-2751.

Infrared/Ultrasonic Position-Measuring System

Position coordinates are calculated from three distance measurements.

Marshall Space Flight Center, Alabama

A system for measuring the positions of sensors at designated points on a body suit is being developed. The measuring system, body suit, and sensors are to be incorporated into an interactive virtual-reality system, wherein they would provide feedback data on the positions and orientations of various parts of the wearer's body. The system is based on the straightforward concept of computing the three-dimensional coordinates of a sensor from simultaneous measurements of the distances of the sensor from three locations, the coordinates of which are known (see figure).

The principle of measurement is essentially the same as that of a popular technique that has been used for many years to estimate the distance of a lightning stroke; namely, by watching the flash and counting the time until one hears the thunder. For this purpose, the system includes a transmitting unit at each of the three known locations. Each transmitting unit emits an infrared pulse (analogous to the visible flash) and an ultrasonic chirp (analogous to thunder) simultaneously.

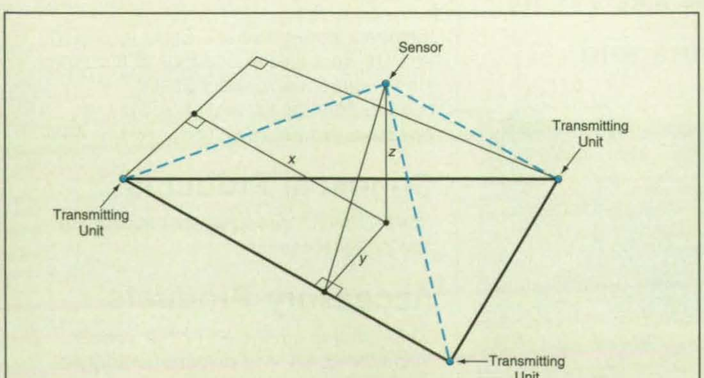
An infrared sensor at each body location detects the infrared pulse (which travels at the speed of light) and the output of the sensor triggers a crystal-controlled timer. A short time later, an ultrasonic sensor at the same location receives the corresponding chirp (which travels at the speed of sound); the output of this sensor causes the timer to stop. Because the time of travel of the infrared pulse is negligibly small in comparison with the time of travel of the ultrasonic pulse, the interval of time thus measured is a close approximation of the distance between the transmitter and the sensor, divided by the speed of sound. Thus, multiplication of the time interval by the speed of sound gives the distance.

When pulses from the other two transmitting units have been similarly received by the sensor, the distances from the body location to the other two transmitting units can also be established. The three-dimensional coordinates of the sensor are then computed by inserting the three distances into the algebraic solution of the simultaneous equations for the spherical surfaces defined by the three distances.

In the fully developed system, all sensor pairs would watch and listen simultaneously for signals from the transmitting units. Thus, a single set of infrared pulses and chirps from each of the three transmitting units would provide sufficient data to calculate the positions of all the sensors. The timers used in a prototype of the system can be turned on and off within two microseconds of receipt of signals from the infrared and ultrasonic sensors. Inasmuch as sound travels less than one millimeter in two microseconds, the calculated position coordinates are expected to be accurate to within about a millimeter. The system operates at up to 30 samples per second and measures distances up to 12 feet (≈3.7 m).

This work was performed by Ricky J. Roberson of Tommorowtools for **Marshall Space Flight Center**. *For further information,* ***write in 76*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26275.



Position Coordinates *(x,y,z)* of a sensor can be calculated, once the distances (indicated by dashed lines) to the sensor from three transmitting units at known locations have been measured.

IC and Circuit Board Development Software System

It will aid in finding new sources of supply for critical parts.

Physical Sciences Directorate, Army Research Laboratory, Fort Monmouth, New Jersey

Far too often the US Army finds itself unable to purchase integrated circuits (ICs) and printed-circuit boards (PCBs) critical to the operation of multimillion-dollar systems. In many cases neither the drawings and schematics nor the original or subsequent suppliers exist. Furthermore, existing documentation may be completely erroneous. As with any owner of very expensive and complex systems that rely on obsolete ICs and PCBs, the Army is working to find ways of developing new sources of supply for critical but unavailable parts.

As part of its continuing mission to solve barrier problems in the electronics area, the Physical Sciences Directorate (PSD) has developed a number of related computer-assisted design modules, called CHIP-SCAN. These utilize optical and electron microscopes to automatically determine the functions of an IC, as well as to automatically generate hardware description models from paper or pixel-image schematics. Using information acquired from the existing documentation or IC, a pin-compatible replacement IC design can be generated and then manufactured using today's technology. Additional design features (*e.g.*, built-in self-test, scan path, reliability, power reduction) can be added within the framework of today's available design software.

As another solution for finding new sources of critical but unavailable electronic parts, PSD has also developed software that can translate IC and circuit-board schematics directly into a machine-readable hardware description model. These can be used by current CAD/CAM software to design masks for production of ICs or PCBs no longer available from any source. Furthermore, the mask design can utilize all technology upgrades that have occurred since the schematic was created.

Benefits of this approach are:

- less power is needed to create designs;
- it is less expensive to make the new chip or board;
- newer technology can be utilized;
- the new design will have greater reliability;
- it will be less expensive to maintain; and
- new functions can go on the same chip or board.

Potential users include aircraft manufacturers, large radar-system manufacturers, IC manufacturers, large construction/earthmoving equipment, and the automotive industry for resupply of parts on demand.

This work was done at the **Physical Sciences Directorate, Army Research Laboratory**, *Ft. Monmouth, NJ. PSD is looking for a CRADA partner or partners to complete the development and integration of these capabilities into a fully capable, commercially valuable system. PSD has filed four patent disclosures, and can offer partners an exclusive commercial license for intellectual property created during the research agreement.*

For further information, contact Gerald T. Michael, ARL Physical Sciences Directorate, AMSRL-PS-EA, Ft. Monmouth, NJ 07703-5601; (908) 427-2283; FAX (908) 427-4323; E-mail: gmichael@army.mil.

Electronic-Lifetime Spectrometer and Microscope

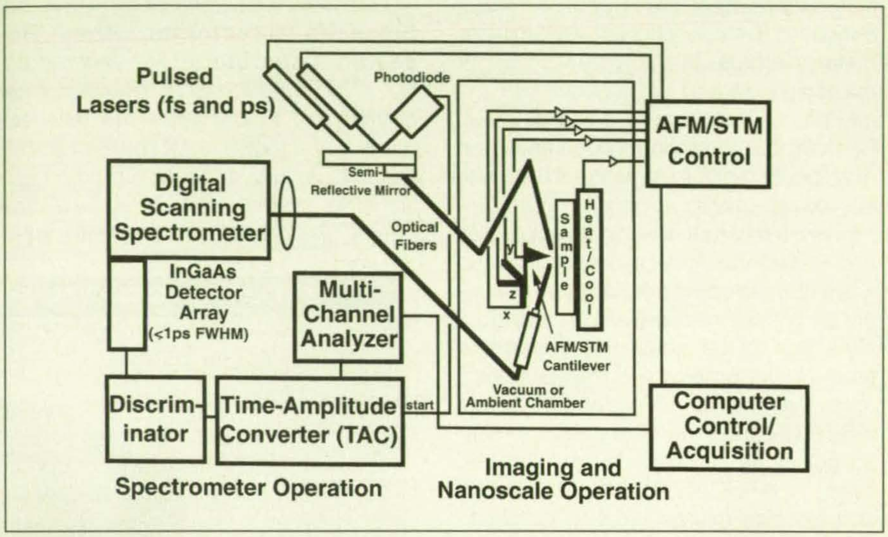
A novel, sensitive, and accurate instrument operates as an integrated spectrometer and microscope.

National Renewable Energy Laboratory (NREL), Golden, Colorado

The electronic-lifetime spectrometer and microscope (ELSAM) is two highly sensitive and accurate instruments—a spectrometer and a microscope—integrated into a unit. As a spectrometer, the ELSAM measures and evaluates fundamental electro-optical properties of semiconductor materials with a resolution that extends to the nanoscale. As a microscope, it makes topographic images that, at its highest resolution, can detect single atoms. The output of these two functions, which can be displayed for a single point or over a selected area, complement each other, providing a basis for comparative analyses.

The figure indicates how the ELSAM operates. As a spectrometer, the ELSAM measures a sample's photoluminescent signal generated by the input from a pulsed laser. To determine the lifetime of electrons or holes in a semiconductor, the pulse conditions (wavelength, power, pulse duration, and repetition rate) of the input laser are matched to the semiconductor. The ELSAM then detects and converts each photon to an electrical signal. As the pulse of the input laser ceases, the output signal decays with a time characteristic of the life of the electrons or holes. The ELSAM quickly analyzes this decay to determine the carrier lifetime. The ELSAM can be used to analyze a single point on a sample, or the incoming laser beam can be scanned over a selected area to provide an area map of the output signal.

For imaging, the ELSAM uses a specially developed atomic force microscope/scanning tunneling microscope (AFM/STM). In one mode of operation the instrument can scan sample dimensions to 100 μm, producing a topographic picture that complements the microscale lifetime data evaluated by the spectrometer.



Functional diagram of the **Electronic Lifetime Spectrometer and Microscope**.

In a second mode of operation, the ELSAM extends both the spectroscopic analysis and the topographic imaging to the nanoscale (in the 30- to 300-nm range). To do this, the instrument employs a specially designed AFM cantilever that allows a voltage to be applied directly between the tip of the cantilever and the sample surface, like an STM. The interaction between this electric field and the photon field enhances the spatial resolution of the light source beyond conventional "wavelength limitations," to produce nanoscale resolution. In this mode, the ELSAM can use complementary information on lifetime, electronic levels, and atomic images to identify chemical and physical defects directly.

The ELSAM uses a computer to control the positioning of the input probes, sample positioning, and data acquisition. The computer also creates two- and three-dimensional representations of the surfaces and of the spectroscopic digital output data. The menu-driven software is user friendly and completely open for modification by the user. The ELSAM also has the capability to generate digital computer videos.

Work on the ELSAM was done by Dr. Richard K. Ahrenkiel and Dr. Lawrence L. Kazmerski at the **National Renewable Energy Laboratory**. *Inquiries concerning patent status or availability of rights and licenses should be directed to NREL's Technology Transfer Office at (303) 275-3008.*

Circular Metal/Semiconductor/Metal Photodetectors

Response times should be smaller and shorter, and breakdown voltages should be larger.

Langley Research Center, Hampton, Virginia

Metal/semiconductor/metal (MSM) photodetectors with multiple concentric circular electrodes are being developed. Some of the electrical characteristics of these devices are expected to be superior to those of older MSM photodetectors that contain interdigitated straight electrodes.

Of the possible circular-electrode configurations, the split-ring configuration shown in the figure is easiest to fabricate. Theoretical analysis indicates that the size of the central disk is critical: the disk must be large enough to keep the breakdown voltage high, but not so large as to shadow a large area of the semiconductor and thereby decrease quantum efficiency. An alternative configuration of two intertwining spiral electrodes has also been proposed, but found to be undesirable.

In comparison with interdigitated straight electrodes, the concentric circular electrodes are expected to provide an improved electric-field configuration that should enable these devices to withstand higher breakdown voltages and to exhibit shorter response times if a satisfactory process can be developed that avoids the need for the split-ring

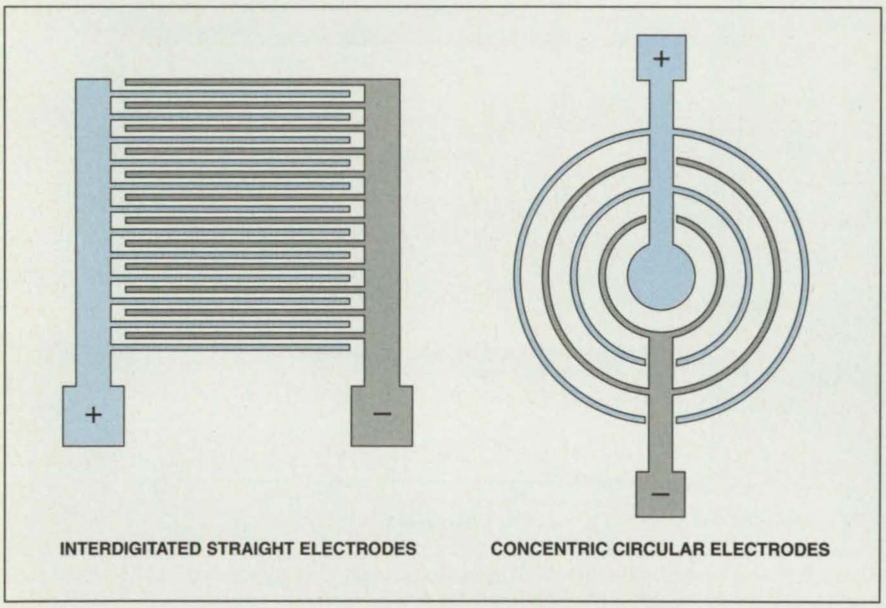
configuration. The capacitance of a typical concentric-circular-electrode device is expected to be about 30 percent lower than that of a comparable straight-interdigitated-electrode device.

The decrease in capacitance allows greater signal-detection bandwidth. This would be an important advantage in fiber-optic telecommunication systems, in which photodetectors are the central components in receiver circuits. Increasing the bandwidth of such a photodetector would enable the receiver to handle a larger number of channels or an increased information rate in each channel.

Another advantage of the circular photodetector pattern is that it would match the circular shape of the cross sections of the light beams from many optical sources. With appropriate choice of wavelength of the optics used to focus light onto a photodetector and of the electrode spacing in the photodetector, it should be possible to locate the maximum-brightness parts of the diffraction pattern in the spaces between the electrodes to maximize the utilization of light, thereby maximizing the output of the photodetector.

This work was done by James A. McAdoo of **Langley Research Center**; *Elias Towe and William L. Bishop of the University of Virginia; and Liang-Guo Wang of the College of William and Mary. No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-15172.



Concentric Circular Electrodes are expected to provide an improved electric-field configuration, with lower interelectrode capacitance and higher breakdown voltage than are possible with interdigitated straight electrodes of comparable dimensions.

Long-Wavelength-Infrared Hot-Electron Transistor

Dark current is reduced by an energy-discriminating quantum filter.

NASA's Jet Propulsion Laboratory, Pasadena, California

The very long-wavelength-infrared hot-electron transistor has been developed at NASA's Jet Propulsion Laboratory. This device detects photons at wavelengths around 16 µm. It comprises a photodetector integrated with an energy-discriminating quantum filter in a multiple-quantum-well structure (see Figure 1). The device is made of variously doped and undoped layers of GaAs (quantum wells) and $Al_xGa_{1-x}As$ (the barriers between the wells).

In this transistor, a bound-to-continuum GaAs/$Al_xGa_{1-x}As$ multiple-quantum-well infrared photodetector (QWIP) serves as a photosensitive emitter. A wide quantum well serves as the base, and there is a thick barrier between the base and the collector. The combination of this barrier

and the base quantum well acts as an energy-discriminating filter: electrons with higher energies pass through this filter to the collector, while those with lower energies are blocked and are diverted from the output-current path through the base contact.

The energy-discriminating filter solves one of the problems that arises in the use of QWIPs; namely, how to reduce dark current, which is relatively large and thus adversely affects performance. In developing the present device, it was found by a combination of theory and experiment that at operating temperatures below approximately 50 K, the dark current in a QWIP is dominated by quantum-mechanical tunneling. More specifically, it was found that thermionic contribution to the dark current in this temperature range is less than the contribution of quantum-mechanical tunneling (including both thermionically assisted tunneling and sequential tunneling through all of the quantum wells). It was also found that the conduction-band electrons that participate in the tunneling current have energies less than those of the photoelectrons. Thus, an energy-discriminating filter that could prevent the lower-energy tunneling electrons from reaching the collector could reduce the output dark current significantly in a QWIP operating in this temperature range.

The present device was grown on a semi-insulating GaAs substrate by molecular-beam epitaxy. A heavily doped (10^{18} cm^{-3}) layer of GaAs 1 μm thick was deposited as the emitter contact. This was followed by a 50-period multiple-quantum-well region of 65-Å-thick doped (5×10^{17} cm^{-3}) GaAs well layers alternating with 500-Å-thick undoped $Al_{0.11}Ga_{0.89}As$ barrier layers. Next, a base-contact layer doped to 3×10^{17} cm^{-3} was grown 500 Å thick. On the base-contact layer, an energy-discriminating barrier layer of undoped $Al_{0.11}Ga_{0.89}As$ was grown 2,000 Å thick. A top collector-contact layer of GaAs was deposited to a thickness of 0.5 μm.

In tests, the device was cooled and back-illuminated at various wavelengths through a 45° polished facet, while its electrical response was measured. Figure 2 shows emitter and collector responsivity spectra measured at a temperature of 60 K. The detectivity was found to increase dramatically with temperature, reaching 10^{12} cm•$Hz^{1/2}$/W at 25 K, and higher at lower temperatures. In contrast, the detectivities of HgCdTe detectors become saturated as temperature decreases.

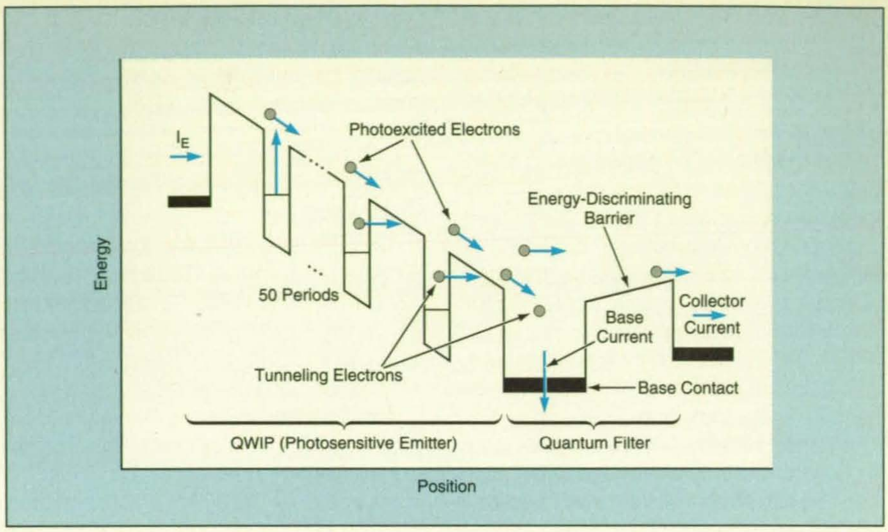


Figure 1. This **Conduction-Band Energy Diagram** illustrates the multiple-quantum-well structure. The quantum filter enhances performance by diverting low-energy electrons that contribute to dark current.

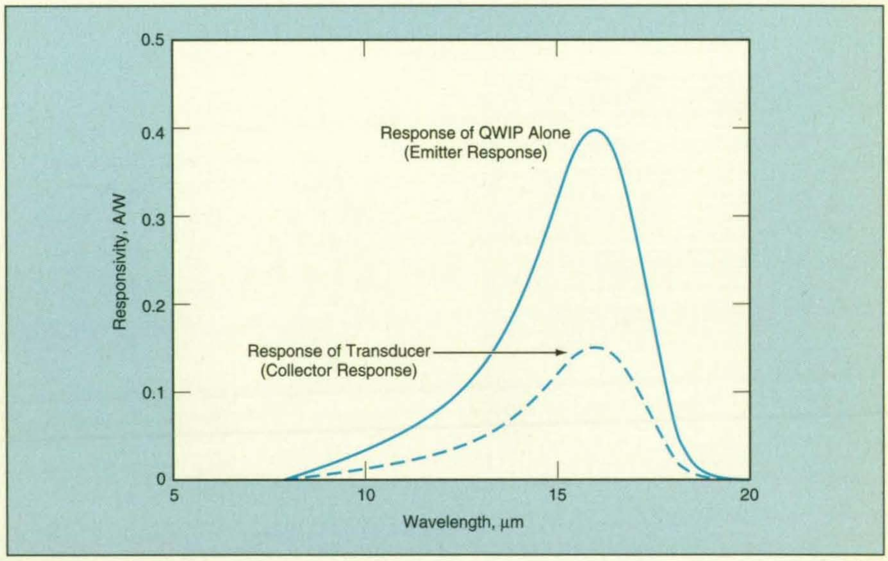


Figure 2. These **Spectral Response Curves** were obtained at a temperature of 60 K with the base and collector contacts grounded and the emitter biased at −1 V.

This work was done by Sarath D. Gunapala, John K. Liu, Jin S. Park, and True-Lon Lin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 29*** *on the TSP Request Card. NPO-19305*

Debris-Free Plasma Radiation Source for EUV Lithography

An E-beam-driven gas-target radiator would be an efficient extreme-ultraviolet (EUV) microlithography tool.

Physics Division, Los Alamos National Laboratory (LANL), Los Alamos, New Mexico

Microelectronics manufacturers continue to improve the performance of computer processors relentlessly. Improvements are accomplished by packing a higher density of circuit elements into a single computer chip. Such densities are achieved by shrinking the elements' feature size. These sizes, today approximately 0.5 μm, are anticipated to shrink to 0.1 μm over the next decade.

These microscopic circuit elements are imaged onto a silicon wafer by photolithographic projection. Achieving 0.1-μm features will demand future lithographic techniques such as extreme ultraviolet

(EUV) radiation, a light source with a considerably shorter wavelength than that currently used in microcircuit imaging. Most of the proposed EUV lithography sources involve the interaction of a high-energy density source (*e.g.*, laser, electron beam, or arc discharge), with a solid target. Although all of these methods offer efficient production of the EUV radiation, debris generated by the target may degrade the system's reflective imaging optics.

Los Alamos and Northrop Grumman are developing a debris-free EUV lithography source. It exploits the predicted anomalous energy deposition of a short-pulse electron beam in a preformed plasma derived from a supersonic gas jet; consequently, the gas is heated and ionized to a charge state at which efficient radiation at 13 nm or less can be generated.

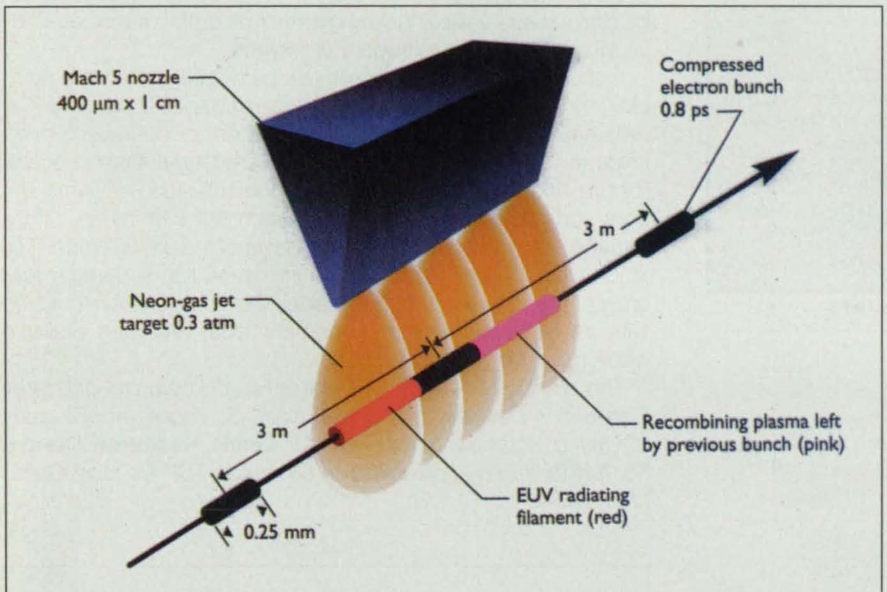
Currently a short-pulse high brightness accelerator developed by the Los Alamos Accelerator Technology Division produces the electron beam. This novel, low-cost accelerator employs a photocathode technique developed at Los Alamos to generate 15-ps electron bunches containing a 5 nC charge with an energy of 8 MeV—the optimum energy needed to maximize EUV output without nuclear activation of the hardware. A time-of-flight electron buncher, which uses the energy spread created in the acceleration process, compresses the bunch to form a 0.8-ps long micropulse. (Compression is desirable for efficient heating of the gas jet.)

The micropulses are produced at a repetition rate of 108 MHz over a 20-μs macropulse period when radio frequency power is applied to the accelerator cavities. Repetition rate of the macropulse is 20 Hz. During a short start-up phase, the first few electron micropulses create a weakly ionized plasma by purely classical collision ionization of the gas. After a critical electron density is reached, the plasma responds collectively to the electron micropulse, and a large-amplitude plasma wave is generated. This wave efficiently slows the high-energy electron beam while heating the background plasma electrons. The latter rapidly heat and ionize the gas jet and reach a final equilibrium in a few tens of picoseconds.

EUV generation demands a near-atmospheric gas jet for the effective transfer of beam energy into the plasma. With a neon gas jet, an efficient filamentary radiator of line radiation near the 13-nm wavelength can be created. Significant radiation, which can also be emitted at 1 nm, would make this technology an attractive candidate source for biological imaging.

The Los Alamos team completed a proof-of-principle experiment to demonstrate the anomalous-energy-loss process, confirming supercomputer computations performed by the Los Alamos Applied Theoretical Division. Although this initial work was performed at low density and with uncompressed electron bunches, the team is near completion of a short-pulse accelerator needed for EUV production. Experiments to demonstrate debris-free EUV generation are expected to be completed by the end of this year.

This work was done by the **Physics Division, Los Alamos National Laboratory**, *Los Alamos, NM. For more information, contact R.D. Fulton, Hydrodynamic and X-ray Physics Group (P-22), MS D440, Los Alamos, NM 87545; (505) 667-2652.*



Schematic of an **EUV source** that can produce debris-free radiation for microlithography. A short-pulse electron beam passes through a plasma derived from a supersonic gas jet; the gas is heated and ionized to a charge state that produces radiation at a wavelength of 13 nm or smaller.

Lightweight Solar Photovoltaic Blankets

Efficient arrays of stacked cells are integrated into laminated sheets.

Lewis Research Center, Cleveland, Ohio

Lightweight, flexible sheets that contain arrays of stacked solar photovoltaic cells are being developed to supply electric power aboard spacecraft. Solar batteries that satisfy the stringent requirements for operation in outer space should also be readily adaptable to the terrestrial environment. These flexible solar batteries could be especially attractive for use as long-lived, portable photovoltaic power sources.

The cells are based on amorphous silicon instead of crystalline silicon, which until now has been the major solar-cell material. The reason for this choice is that the unique combination of physical and chemical properties of amorphous silicon offer potential for order-of-magnitude increases in power per unit weight, power per unit volume, and endurance in the presence of ionizing radiation. In addition, technology for manufacturing amorphous silicon cells and arrays of cells has now matured.

The basic unit cell is of the p/i/n type: it comprises an undoped (intrinsic; i) layer sandwiched between an electron-acceptor-doped (p) layer and an electron-donor-doped (n) layer. For reasons grounded in the basic physics of photovoltaic devices, it is necessary to make the intrinsic layer thin (typically, no thicker than a few thousand Å) to maximize the efficiency of conversion of intercepted photons and to minimize the degradation of efficiency with continued expo-

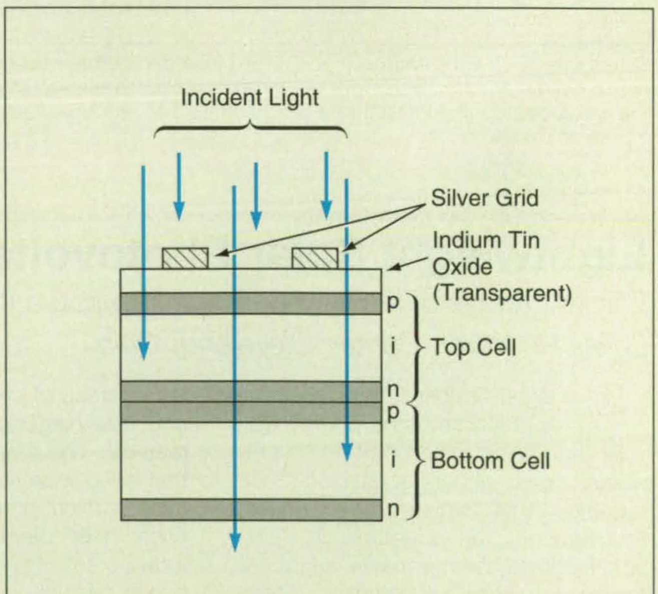
sure to both light and ionizing radiation.

Unfortunately, thinning a cell reduces the fraction of incident photons that the cell can intercept and thereby imposes a fundamental limitation on overall energy-conversion efficiency. The stacked-cell configuration (see figure) of the developmental solar photovoltaic blankets helps to overcome this limitation by providing subsequent cell layers that can intercept photons that have passed through previous cell layers. One can increase the utilization of the solar spectrum and thus the overall energy-conversion efficiency by making the intrinsic layers of the stacked cells out of materials that have different bandgaps, so that each cell in the stack captures predominantly photons in a different wavelength range.

The design of an optimum stacked-cell structure is a complex task that requires consideration of numerous physical effects and physical properties of materials, including those mentioned above. Theoretical calculations have shown that a stack of three cells that have intrinsic layers with bandgaps of 1.7, 1.4, and 1.1 eV, respectively, should operate at an efficiency between 20 and 24 percent. Amorphous silicon alone has a bandgap of about 1.7 eV, and materials with various bandgaps can be made by alloying amorphous silicon with other elements; bandgaps can be decreased by alloying with germanium or tin, or increased by alloying with carbon, nitrogen, or oxygen.

A sheet array of stacked cells can be manufactured in a complex, multiple-step process in a roll-to-roll deposition facility. The cells are formed on a substrate of Kapton (or equivalent) polyimide, with a reflective back layer of alternating sublayers of aluminum and zinc oxide to increase the utilization of light. The front-surface electrical contact to each stack is made with a transparent, electrically conductive layer of indium tin oxide. The stacks are connected together into modular subarrays and arrays by screen-printed silver grids. The entire sheet is covered with an ultraviolet-resistant polymeric coat and with a silicon oxide top coat.

This work was done by R. Ceragioli and R. Himmler of Energy Conversion Devices, Inc., and P. Nath, C. Vogeli, and S. Guha of United Solar Systems Corp. for **Lewis Research Center.** *For further information,* ***write in 58*** *on the TSP Request Card.* *LEW-15545*



Stacked Thin Photovoltaic Cells can convert light to electricity more efficiently than can a single thick cell. Each cell in the stack can be designed to intercept photons in a different wavelength range.

High-Performance Dielectric Resonator Oscillators (DROs)

These new devices, whose specifications surpass current commercially available DROs, are suitable for many applications.

Physical Sciences Directorate, Army Research Laboratory, Fort Monmouth, New Jersey

ARL Physical Sciences Directorate designs, builds, and evaluates ultrastable, low-noise dielectric resonator oscillators (DROs), at microwave and millimeter-wave frequencies, that are suitable for many applications. These oscillators are lightweight, small, and low in cost compared to other types of oscillators, and can benefit radar and communications systems. The phase noise and frequency stability of these oscillators, over extended temperature ranges, surpass commercially available DROs, and do so without any temperature compensation techniques.

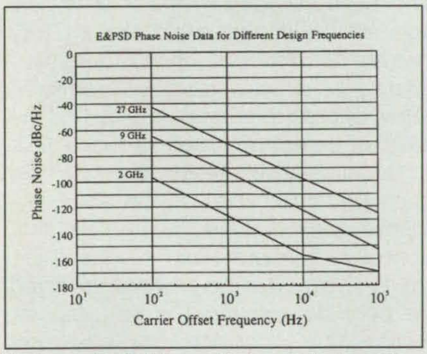


Figure 1. **DRO Phase-Noise Data** for different design frequencies.

The 9-GHz DRO demonstrated a SSB phase-noise level of -65 dBc/Hz at a 100-Hz carrier offset frequency (Figure 1), an improvement of 8 dBc/Hz over any previously published results. The stability-vs.-temperature figure also demonstrated superior results (see Figure 2). The total frequency drift over the full temperature range of -50 to +50 °C was only 65 parts per million (ppm).

The output power variation over the same temperature range was less than ±0.4 dB, or a 1.5-mW variation compared to a 16.5-mW total output power. This frequency and output power stability and phase noise far surpass commercial DROs without temperature compensation. Such performance has been demonstrated at S-band, X-band, Ku-band, and K-band.

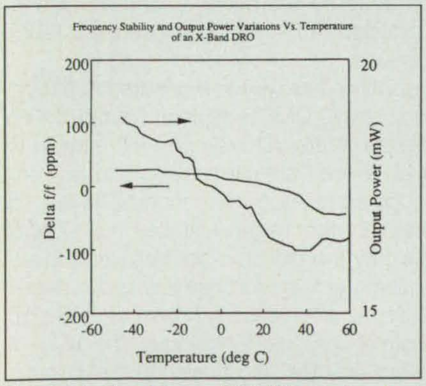


Figure 2. **Frequency Stability** and output power variations vs. temperature of an X-band DRO.

Among potential commercial uses are direct broadcast satellites, distress beacons, cellular telephones, test instrumentation, telecommunications systems, satellite transmission, identify friend or foe and airborne radar systems, burglar alarms, and CATV converters.

This work was done at the **Physical Sciences Directorate, Army Research Laboratory**, *Ft. Monmouth, NJ. For additional information, contact Muhammed Mizan, Dana Sturzebecher, or Thomas Higgins at the ARL Physical Sciences Directorate, AMSRL-EP-E, Ft. Monmouth, NJ 07703-5601; (908) 427-4415; FAX (908) 427-4323; E-mail: mmuhamm2arl.mil.*

Semiconductor/High-T_C-Superconductor Hybrid ICs

Sapphire substrates help to prevent diffusion of Cu from superconductors into semiconductors.

Lewis Research Center, Cleveland, Ohio

Hybrid integrated circuits (ICs) that contain both Si-based semiconducting and $YBa_2Cu_3O_{7-x}$ superconducting circuit elements on sapphire substrates are being developed. [$YBa_2Cu_3O_{7-x}$ is called a high-temperature or high-T_C superconductor because its critical temperature for transition to superconductivity (T_C) is above the temperature of liquid nitrogen (77 K) — higher than that of previously known superconductors.] These hybrid ICs can combine superconducting and semiconducting features that are unavailable in superconducting or semiconducting circuitry alone — for example, complementary metal oxide/semiconductor (CMOS) readout and memory devices integrated with fast-switching Josephson-junction superconducting logic devices and zero-resistance interconnections.

Previous attempts to integrate high-T_C superconductors with Si or GaAs devices have been thwarted by major obstacles. High-T_C superconductors are oxides that are chemically very weakly bound and hence are decomposed (often into elemental copper and other metals) by direct contact with semiconductors. Elemental copper diffuses through Si, GaAs, and Ge faster than does any element except hydrogen; at typical processing temperatures, Cu can move centimeters in a few hours. Copper forms deep electronic traps in Si, Ge, and GaAs and hence destroys those semiconducting properties that make these materials useful in transistors and integrated circuits. Although simple high-T_C films can be grown on buffered silicon, they have never been demonstrated to be useful for making Josephson junctions (the superconducting equivalent of a transistor).

The use of sapphire (Al_2O_3) substrates for both the semiconducting and superconducting circuit elements in the developmental hybrid ICs helps to overcome these obstacles because high-T_C materials are relatively chemically stable on sapphire, and copper does not diffuse through sapphire. Thus, the paths for diffusion of copper through a substrate from the superconductor devices to the semiconductor devices are eliminated, and the fraction of the total IC area that must be protected against diffusion is reduced. As an additional benefit in cases in which silicon-based devices are not connected to each other by direct silicon paths, (as is often true of CMOS devices) even if Cu does contaminate a transistor, it cannot diffuse to another. The developmental hybrid ICs also include protective layers of Si_3N_4, which are deposited on the silicon-based devices to act as barriers to the diffusion of Cu during subsequent fabrication of the high-T_C devices.

A representative hybrid IC of this type is fabricated in a four-stage process. In the first stage, CMOS devices are fabricated on a silicon-on-sapphire substrate, and reactive-ion etching is used to strip the Si, down to the bare sapphire substrate, from areas where high-T_C-superconductor interconnections are to be formed subsequently. In the second stage, the CMOS devices are encapsulated by the diffusion-barrier layers; these layers are formed by plasma-enhanced chemical vapor deposition of low-stress Si_3N_4 to a typical thickness of 200 nm. By use of standard photolithographic techniques, the Si_3N_4 is patterned so that it covers only the silicon islands that contain the CMOS devices. In the third stage, the $YBa_2Cu_3O_{7-x}$ structures are fabricated. In the fourth stage, holes are made in

the diffusion barriers to provide access to the electrical-contact parts of the CMOS devices.

This fabrication sequence — in particular, doing the Si processing before the $YBa_2Cu_3O_{7-x}$ processing — is dictated by the phase stability of the $YBa_2Cu_3O_{7-x}$. The Si processing involves depositions, diffusions, and annealing at temperatures of the order of 1,100 °C. $YBa_2Cu_3O_{7-x}$ is deposited at about 750 °C and irreversibly decomposes into various copper yttrium and barium oxides at temperatures above approximately 950 °C. The processing temperature for the $YBa_2Cu_3O_{7-x}$ and associated buffer layers never exceeds 800 °C, at which the CMOS structures are quite stable.

This work was done by Michael J. Burns of Conductus, Inc., for **Lewis Research Center**. *For further information,* ***write in 89*** *on the TSP Request Card. LEW-15762*

Large-Scale Laser Scanner for Testing Photovoltaic (PV) Cells

Computerized system identifies defects and variations in performance in PV cells, modules, and submodules.

National Renewable Energy Laboratory (NREL), Golden, Colorado

The SolarScan™ large-scale laser scanner (LSLS) is a versatile tool for investigating new photovoltaic (PV) cells and module designs during research and development, for quality control in a production setting, and for failure analysis of modules after use. It not only identifies problem cells within a module, but also highly localized problem areas within a cell. It is the only instrument available with such capability for large-scale devices and modules. The wavelength-dependent laser-beam-induced current (LBIC) maps from each module quickly reveal problematic cells or areas. In addition, they provide an easy means to compare one module to another, and can also be kept as a diagnostic record for any modules that come back for failure analysis or periodic performance testing.

Current standard qualification testing and module performance testing involve actually operating the modules under various conditions—long, complex processes that provide little insight into what is going on within the module, and none into performance at the cellular level. LSLS provides such insight, easily generating response maps—at any time during the testing process—that can be correlated with observed performance, and pinpointing cells or areas that might be affecting that performance.

The SolarScan LSLS identifies defects and assesses any variation in photoresponse of PV devices, up through full-size modules. Such module characterization is an invaluable diagnostic tool for PV technology that is not provided by other devices. Because most PV modules are made of many interconnected cells encapsulated in protective material, the system acts differently from what the sum of the individual cells would suggest. But other laser or electron-beam scanners are limited to small sample sizes such as single cells, and the hermetically sealed modules cannot usually be taken apart for this kind of analysis without destroying the module.

The SolarScan quickly and easily microcharacterizes any size or shape module of any PV technology, without damaging the module. Its spatial resolution is sufficient for most module characterization needs, and its computer generates output maps that are easy to read and provides additional analytical capabilities. There is no other scanner available that can handle full size modules, and the SolarScan is less expensive and easier to operate than ones available for analysis of small cells.

Two key features of the SolarScan LSLS are use of motor-driven mirrors as the scanning mechanism and sophisticated software that takes advantage of the capabilities of modern Macintosh computers. By using the computer both to guide the laser and to collect and analyze the photoresponse data, researchers at NREL and Laser Designs have created a system that has unprecedented flexibility and analytical capability.

Because the capital cost of PV is high and the operating expense low, its length of operational life is a key factor in its economic attractiveness. So qualification testing, quality control, and failure analysis are crucial, but very difficult with diagnostic tools that cannot handle full-size intact modules. The SolarScan LSLS combines software and computer capability with knowledge of PV microcharacterization technology and techniques. Perhaps as important, it does so at a very reasonable cost.

This work was done at the **National Renewable Energy Laboratory** *in collaboration with Laser Designs, Woodland Park, CO. For more information about the technology, contact Dr. Richard Matson of NREL at (303) 275-3726 or Randall Rico of Laser Designs at (719) 687-3968.*

Inquiries about patent status and availability of rights and licenses should be made to NREL's Technology Transfer Office at (303) 275-3008.

Multilayer Thin-Film Microcapacitors

These devices would be much smaller than state-of-the-art capacitors.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature capacitors containing multiple alternating thin-film dielectric and metal layers have been proposed, especially for use in integrated and hybrid electronic circuits. Because capacitance is inversely proportional to the thickness of the dielectric layers, the use of thin, high-quality dielectric layers would afford capacitance and energy-storage densities much greater than are now available. The volumes and weights of the proposed capacitors could be made a hundred times less than those of equivalent state-of-the art capacitors — an important advantage in power- and signal-handling circuits, in which capacitors typically occupy 15 to 80 percent of the circuit-board area and contribute about 30 percent of the weight. In comparison with state-of-the art capacitors, the proposed capacitors could also be made more reliable.

The figure is a schematic cross section of a typical multilayer thin-film capacitor. Capacitors of this type could be formed on silicon and gallium arsenide substrates along with other integrated-circuit components by use of thin-film-deposition and masking techniques compatible with other integrated-circuit-fabrication techniques. One of the advantages of the configuration illustrated in the figure is that only two sets of deposition masks would be needed; the sets would be used alternately to obtain the desired serpentine winding of the dielectric layer between stacked metal layers connected alternately to external contacts to form two electrodes.

The thin-film dielectric materials in the proposed capacitors will likely be perovskite ceramics like lead magnesium niobate, lead lanthanum zirconate titanate, and barium strontium titanate. Multilayer ceramic capacitors, which are the most compact state-of-the-art capacitors, contain dielectric layers of these and similar materials in "bulk" form, made by screen printing, followed by sintering. Despite the high relative permittivities (500 to 20,000) and high breakdown electric fields ($\approx$1,000 V/μm) inherently achievable in such crystalline ceramics, the dielectric layers in multilayer ceramic capacitors exhibit breakdown electric fields of only $\approx$10 V/μm. This disparity between the inherent and actual values is due to the defects, impurities, and voids introduced during processing.

The use of these materials in conjunction with thin-film deposition techniques, as distinguished from sintered bulk forms of these and similar materials, would offer the potential for significantly better quality; in comparison with their sintered bulk counterparts, the thin-film materials would be denser and smoother, would contain fewer and smaller voids, and could be deposited with control over chemical compositions and grain sizes. Thin-film technology offers the option of selecting from among a wider variety of materials with high relative permittivity and high temperature stability.

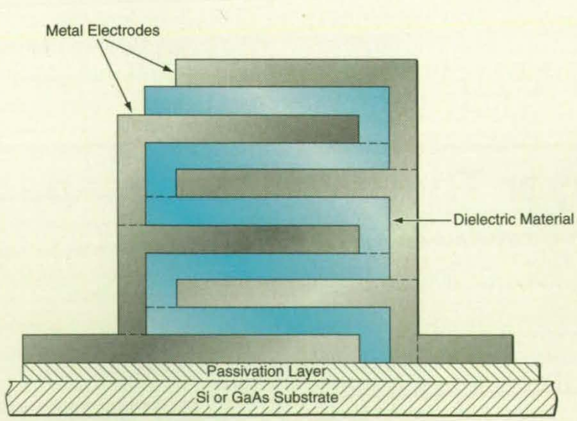
It will be necessary to solve some practical problems in developing the proposed capacitors. One problem is to develop and refine deposition processes to obtain dielectric films with acceptably low densities of defects in thicknesses up to about 1 μm. Another problem is posed by the fact that depending on specific compositions, the crystalline structures of the candidate dielectric materials can exhibit piezoelectric, pyroelectric, and ferroelectric properties simultaneously. Pyroelectricity leads to large variations in the permittivity (and thus capacitance) with temperature, while piezoelectricity gives rise to mechanical stresses proportional to applied potentials. Piezo-electricity could be especially troublesome because the resultant mechanical stresses could crack the dielectric films. The choice of material for a specific application must be based partly on consideration of these effects, and the material and/or the specific configuration must be chosen to resist or compensate for these effects.

This work was done by Sarita Thakoor, Anil Thakoor, and Dan Karmon of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 43*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19403, volume and number of this NASA Tech Briefs *issue, and the page number.*



A **Multilayer Thin-Film Microcapacitor** would be fabricated by depositing layers of a high-permittivity dielectric material alternately with layers of metal, using two sets of masks in alternation.

Battery State-of-Charge Device

An indicator saves money by ensuring full utilization of battery capacity.

Physical Sciences Directorate, Army Research Laboratory, Fort Monmouth, New Jersey

Prediction of the remaining capacity of used batteries is important information to the user. Each year millions of dollars are spent on batteries, and much of this investment is wasted. In order to maintain readiness, users typically replace batteries on a conservative schedule, resulting in the waste of millions of dollars in battery energy. One estimate indicates that as much as 40 percent of available battery capacity is discarded. For many systems there is no convenient method of determining the capacity remaining in partially used batteries.

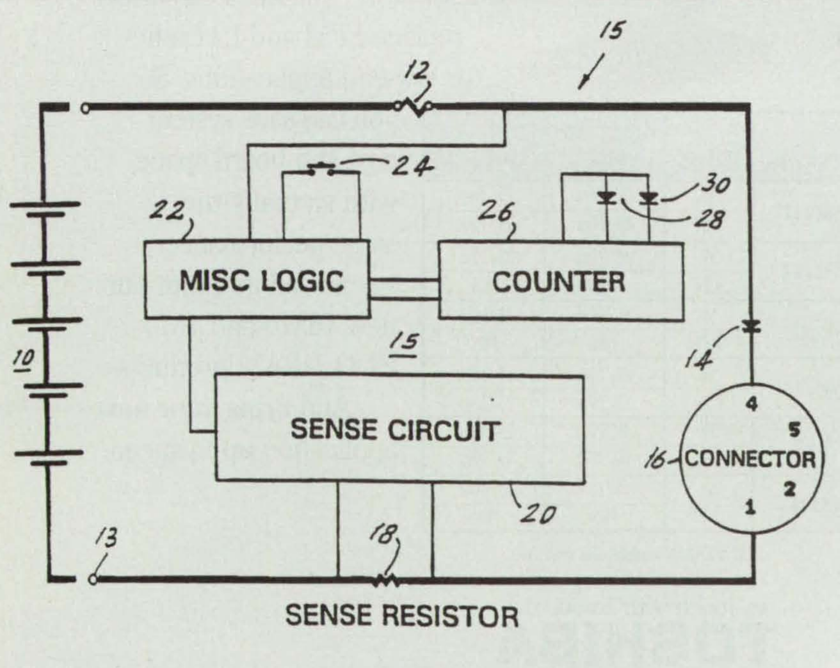
It is well accepted that the available capacity in a battery is a function of the discharge conditions. Capacity remaining is a complex function of current drain, temperature, and time, relating to the efficiency of the electrochemical system. External state-of-charge devices are available for most battery systems. However, these devices cannot completely determine the past history of a discharged battery, and are in many cases imprecise. Although a continuous internal means of gauging remaining capacity is desirable, such a device must continually monitor discharge conditions and determine the remaining capacity based on the known electrochemical efficiency. Past internal methods required extensive calibration, and in some cases were difficult to implement.

A universal state-of-charge indicator has been elusive because of the variations in behavior of battery systems. But an effort at ARL has resulted in a "Universal Inexpensive Battery State-of-Charge Indicator" (US Patent 5,372,898, Atwater, Dratier, et al., assigned to US as represented by the Secretary of the Army, and others pending).

The figure, extracted from the patent, is a block diagram of the indicator. The sense circuit, along with the sense resistor, utilizes a pair of P-N-P transistors, a capacitor, and additional electronic components as an inexpensive current integrator. Both the sense circuit and the miscellaneous logic are calibrated and tuned to account for the efficiency of the electrochemical system at various discharge rates and temperatures. Additionally, the miscellaneous logic contains the ability for the system to be reset when used in a rechargeable battery. The counter stores the information from the miscellaneous logic so the user can obtain the remaining capacity in real time. This configuration thus makes the circuit a viable state-of charge indicator for all electrochemical systems.

Summing up the device's capabilities: it works with all battery chemistries; is small, inexpensive, and rugged; and is useful for both primary and rechargeable batteries. It saves money by ensuring full utilization of capacity, insures emergency and back up batteries are ready, and prevents down time. Incorporation of this technology in future battery procurements will reduce O&S costs and enhance mission capabilities through complete usage of available battery energy.

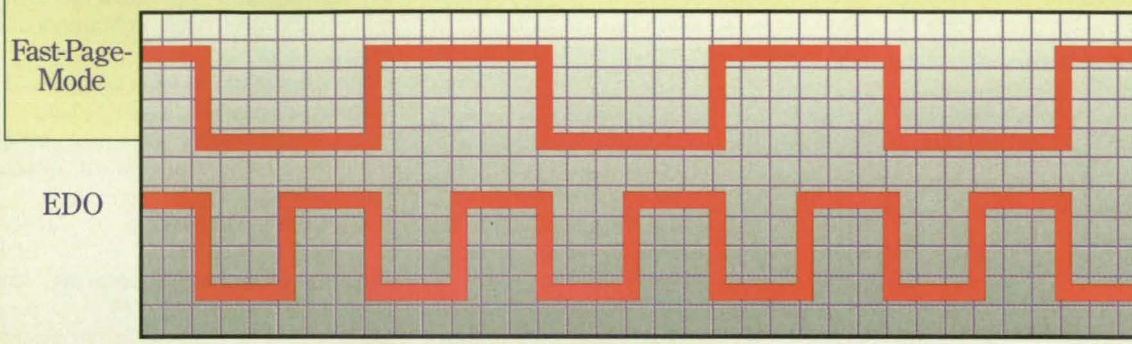
This work was done by Terrill B. Atwater and Richard M. Dratier of the **Physical Sciences Directorate, Army Research Laboratory**, *Ft. Monmouth, NJ 07703. For more information, contact Mr. Atwater at ARL Physical Sciences Directorate, AMSRL PS-CA, Ft. Monmouth, NJ 07703-5601; (908) 427-3549; FAX (908) 427-3665; E mail: tatwater@arl.mil.*



Block diagram of the **Universal Inexpensive Battery** state-of-charge indicator extracted from the patent.

Extended-Data-Out DRAM

Compared to Fast-Page-Mode, our new EDO is a real speed reader.



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Device Type	Voltage	Access Time (tRAC)	Cycle Time
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	3.3V	60/70ns	25/30ns
512K x 32	5V	60/70ns	25/30ns
	3.3V	70ns	30ns
1M x 16	5V	60/70ns	25/30ns
	3.3V	70ns	30ns
4M x 4	5V	60/70ns	25/30ns
	3.3V	60/70ns	25/30ns
2M x 8	5V	60/70ns	25/30ns
	3.3V	60/70ns	25/30ns
1M x 18	5V	60/70ns	25/30ns
	3.3V	70ns	30ns

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Improved Method of Bending Concentric Pipes

Bending could be done faster and more cleanly, and it could be largely automated.

NASA's Jet Propulsion Laboratory, Pasadena, California

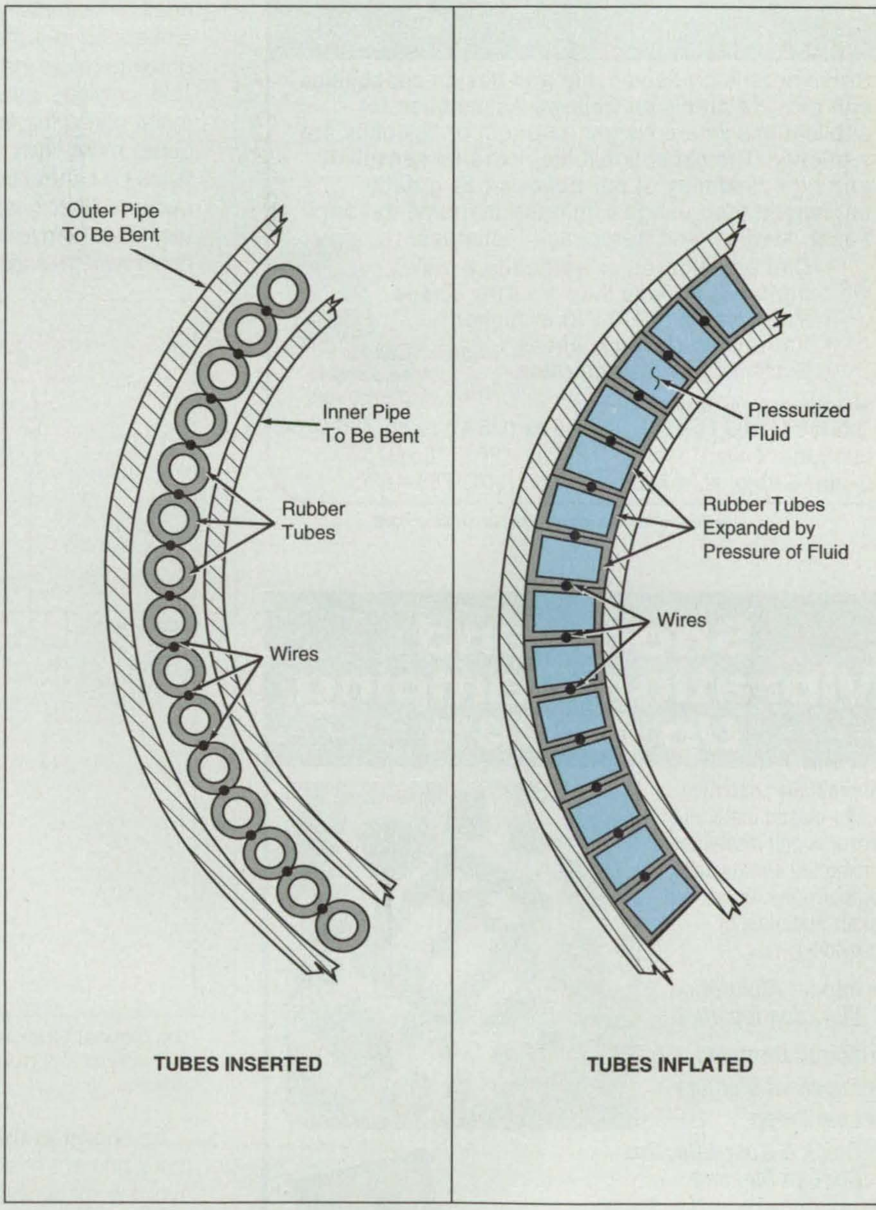
A proposed method for bending two concentric pipes simultaneously while maintaining the void between them would replace the present tedious, messy, and labor-intensive method. The proposed method would enable bending to be done faster and more cleanly, and would be amenable to automation of a significant portion of the bending process on computer numerically controlled (CNC) tube-bending machinery.

In the present method, one fills the interpipe gap with fine metal shot, seals the gap at the ends of the pipes, bends the pipes in a bending machine, unseals the pipes, and cleans out the shot. All of these steps are performed manually and/or by machinery under manual control.

In the proposed method, a CNC machine would first insert, between the concentric pipes to be bent, an array of rubber tubes stiffened by axial wires. A relatively incompressible liquid would be pumped into the rubber tubes and pressurized so that the rubber tubes would fill the gap completely (see figure). The array would be held together at one end by a solid rubber block. At the other end, each rubber tube would be sealed, after pressurization, with a clamping plunger.

The CNC machine would then bend the concentric pipes to the desired curvature. During bending, the inflated tubes would maintain the gap between the pipes, preventing buckling. After bending, the CNC machine would release the clamping plunger to release the pressurized liquid and would remove the tubes from the bent pipes. As the tubes emerged from the bent pipes, the wire stiffeners would restore the rubber tubes to straightness. There would be no shot or other solid residue to clean up.

This work was done by James E. Schroeder of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 108*** *on the TSP Request Card.*



An **Array of Rubber Tubes** would be inserted in the gap between concentric pipes. The tubes would then be inflated with a relatively incompressible liquid to fill the gap.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19089, volume and number of this NASA Tech Briefs *issue, and the page number.*

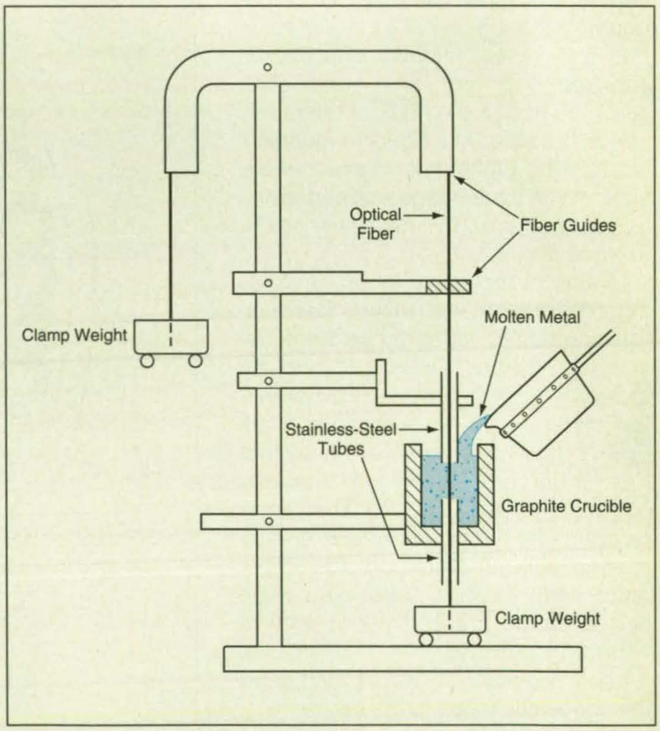
Embedding Optical Fibers in Cast Metal Parts

Use of metal strain reliefs eliminates breakage of fibers during casting process.

Lewis Research Center, Cleveland, Ohio

A technique for embedding fused silica optical fibers in cast metal parts has been devised. An optical fiber could be embedded in a flange, fitting, or wall of a vacuum or pressure chamber, for example, to provide a hermetically sealed feedthrough for optical transmission of measurement or control signals. For another example, an optical-fiber temperature sensor could be embedded in a metal structural component to measure strain or temperature inside the component.

In previous attempts at embedding optical fibers in cast metal parts, the fibers broke at and near the surfaces of the parts, most likely as a result of stresses introduced into the fibers by contraction of the metal during cooling to room temperature after casting. The present technique for embedding the fibers prevents breakage by providing for relief of the cooldown stresses.



The **Optical Fiber Is Embedded by Casting** the metal part around it. Stainless-steel tubes around the fiber are also embedded to relieve stresses.

As shown in the figure, a fiber to be embedded in a cast metal part is first slipped into two narrow tubes made of a metal (typically of stainless steel) that has a melting temperature greater than that of the metal to be cast. The tubes are positioned so that they will stick partly in and partly out of the cast object. The tubes relieve the stresses on the parts of the fiber near the surfaces.

This work was done by William N. Gibler, Robert A. Atkins, Chung E. Lee, and Henry F. Taylor of Texas A & M University for **Lewis Research Center**. *For further information,* ***write in 50*** *on the TSP Request Card. LEW-15233*

Mathematics and Information Sciences

Pseudogradient Training for a Class of Neural Networks

Step activation functions impart stability.

NASA's Jet Propulsion Laboratory, Pasadena, California

Developmental second-order recurrent neural networks of a special type have been modified to enhance their stability in the face of inputs beyond the range of the inputs on which they are trained. Second-order recurrent neural networks contain product feedback units and can be trained, by use of example inputs and outputs, to act as finite-state automatons. The particular second-order recurrent neural networks in question learn grammars in the sense that they are trained to generate binary responses ("legal" vs. "illegal") to input training sequences of ones and zeros, each sequence being marked "legal" or "illegal" according to the grammar to be learned.

During the training of an unmodified network of this type, one presents the network with randomly chosen training strings of various lengths up to some maximum length, and, for each string, seeks to reduce the error in the response of the network by adjusting the network weights (the strengths of the synaptic connections between neurons) according to a gradient descent of an error measure in weight space. The error measure is defined with respect to the output (activation) of one of the neurons in the network that is designated as an indicator neuron: The correct activation of the indicator neuron is 1 if the input string is legal and 0 if it is illegal. The error measure is proportional to the square of the difference between the actual and correct activations.

As training progresses, the unmodified network attempts to form clusters of points in activation space as its internal representation of states. Once training has been completed, the unmodified network acts like a state machine in that its activation point jumps from one cluster to another when presented with input bits one by one, provided that the string of input bits is no longer than the longest training string. However, when presented with longer input strings, the network behaves unstably in that the activation points move out from the clusters: in essence, the unmodified network "forgets" where the individual states are in activation space.

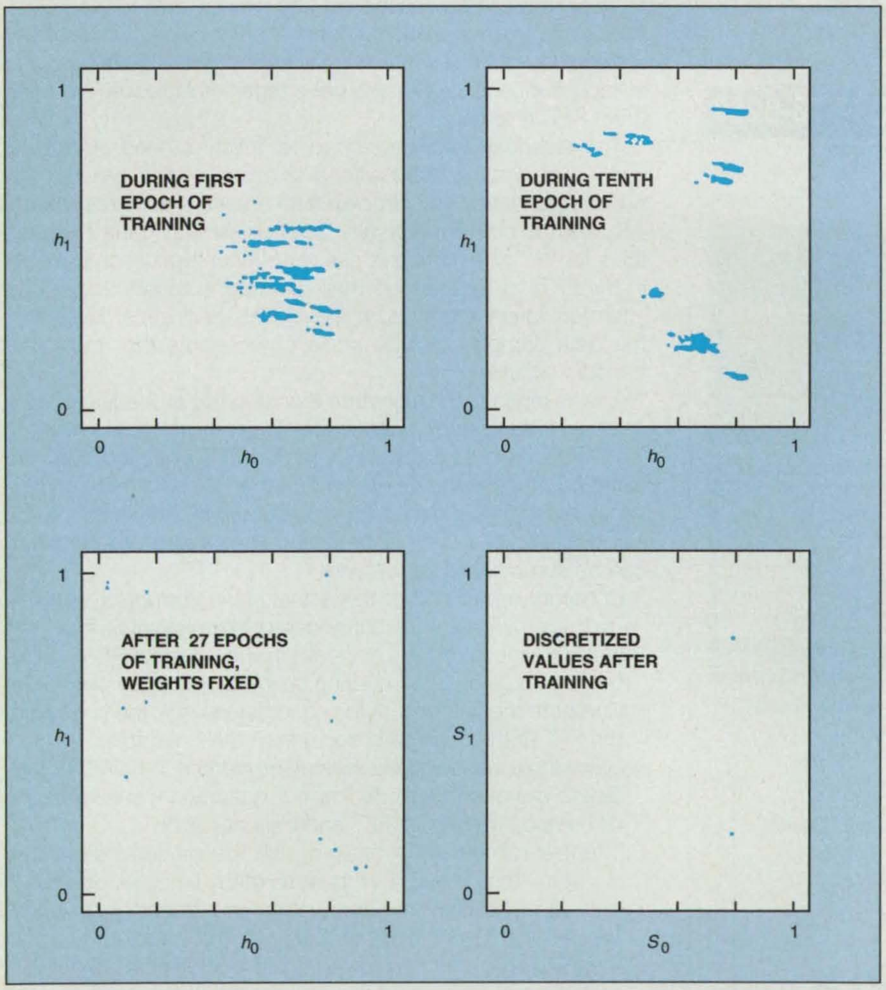
Therefore, two modifications have been made to enable the network to learn stable states; that is, to form clusters such that activation points for long strings also converge to central points within the clusters (see figure). The first modification is replacement of the standard sigmoid activation function

$$f(x) = \frac{1}{1+e^{-x}}$$

with the step function

$$D(x) = \begin{Bmatrix} 0.8 \text{ if } x \geq 0 \\ 0.7 \text{ if } x < 0 \end{Bmatrix}$$

where x is the sum of weighted excitations applied to the input terminal of a neuron. This modification, by itself, would prevent learning by the gradient-descent method because the nondifferentiability of $D(x)$ would make it impossible to examine the effect of small changes in weights on the



These Plots Are Activation-Space Records of a four-hidden-unit second-order recurrent neural network. The plots were recorded during and after training the network according to a grammar called "Tomita Grammar #4." The symbols h_0 and h_1 denote the continuous activation values according to the sigmoids; the symbols S_0 and S_1 denote the discretized (step-function) values.

error measure.

Accordingly, the second modification is the introduction of a pseudogradient method: the sigmoid activation function is used in place of the step function to calculate a gradient (the pseudogradient), which is used only as a guide to locating the steps in activation space and adjusting the weights. The pseudogradient method may also be useful as a basis for training neural networks of other types that involve hard-limiting threshold activation functions.

This work was done by Zheng Zeng, Rodney M. Goodman, and Padhraic J. Smyth of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 56*** *on the TSP Request Card. NPO-18956*

Extracting Periodic Signals From Irregularly Sampled Data

Successive approximations are formed in Fourier space.

NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm extracts periodic signals from sparse, irregularly sampled sets of measurement data. The algorithm pertains to data that are processed via fast Fourier transforms (FFTs). The data can represent signal components with initially unknown frequencies that span a large spectral range and can include frequencies that are not integer multiples of the minimum FFT frequency.

The algorithm was developed to satisfy a need, frequently encountered in the observational sciences, to find periodic signal components with unknown frequencies in samples of data acquired at uneven intervals, sometimes with gaps between the intervals. The gaps give rise to spurious signal components in the FFTs at frequencies that correspond to side lobes and intermodulation products of the signals and gaps. Moreover, the data samples include noise components that mask the periodic signals.

The essence of the algorithm is an iterative procedure of successive refinement of a candidate signal, in which one seeks a least-squares best fit between (a) the FFT obtained from the sampled measurement data and (b) the FFT obtained from the candidate signal sampled (by computational simulation) in the same way as that of the actual data. The steps of the algorithm can be summarized as follows:

1. Compute the FFT from the actual noise-corrupted sampled measurement data (hereafter called "the original FFT").
2. Identify candidate highest peaks in the original FFT, and use them as a guide in computing an initial candidate signal.
3. Compute the samples of the candidate signal, then compute the FFT of the candidate signal from these samples.
4. Following a least-squares best-fit procedure, modify the candidate signal so as to minimize a quadratic measure of the difference between its FFT and the original FFT.
5. If further refinement is desired, use the modified candidate signal in steps 3 and 4. Repeat as many times as desired or until all identifiable frequency components and their amplitudes have been incorporated into the candidate signal, meaning that the candidate signal contains all identifiable periodic components of the actual sampled signal.

This work was done by Jaroslava Z. Wilcox of Caltech for **NASA's Jet Propulsion Laboratory**. *No further documentation is available. NPO-19546*

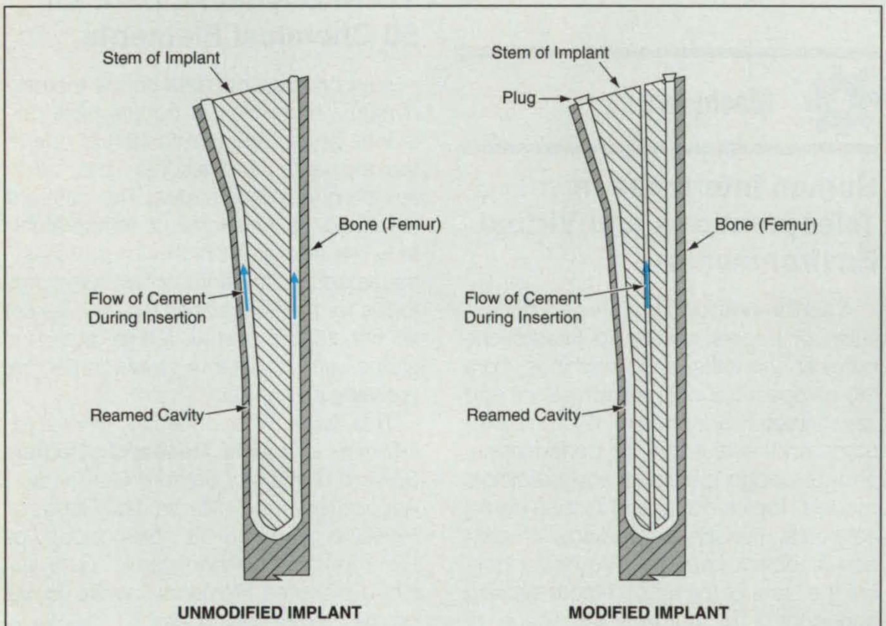
Hip Implant Modified To Increase Probability of Retention

The modification would alter the flow of cement to reduce structural imperfections.

Marshall Space Flight Center, Alabama

A modification in the design of a hip implant has been proposed to increase the likelihood of retention of the implant in the femur after hip-repair surgery. In so doing, the modification would decrease the likelihood of the patient distress and the expense associated with a repetition of surgery after a failed implant procedure. As explained below, the modification is intended to provide a more favorable flow of a cement that is used to bind the implant in the proximal extreme end of the femur, thereby reducing structural flaws that can cause early failure of the implant/femur joint.

An unmodified implant of the type in question includes a solid stem that is inserted into an axial cavity that has been reamed into the proximal end of the femur (see figure). Immediately prior to insertion of the implant, bone cement is placed in the cavity. Then as the stem is inserted, it displaces the adhesive, and the excess adhesive flows to the opening at the top of the bone. According to a numerical simulation, the flow is laminar and characterized by boundary layers, vortices, and other features that can impart structural imperfections that persist as the cement solidifies.



The **Lengthwise Hole in the Modified Implant** would provide a more favorable flow of bone cement during insertion, reducing the severity of structural imperfections that remain after the flow stops and persist as the cement hardens.

The modified implant would resemble the unmodified implant except that its stem would not be entirely solid; the modified implant would contain a lengthwise hole. The gap between the stem of the implant and the bone would be plugged so that the cement could not escape there, then the implant would be pushed slowly into the cement-filled cavity. The excess cement would be forced to flow out through the lengthwise hole. There would be less flow between the cavity wall and the outer surface of the modified insert than in the case of the unmodified insert. Thus, the unfavorable flow patterns and the resulting structural imperfections should be reduced.

This work was done by Francisco Canabal III of **Marshall Space Flight Center**. *For further information,* ***write in 35*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28987.

Portable Immune-Assessment System

Lyndon B. Johnson Space Center, Houston, Texas

A portable immune-assessment system has been developed for use in rapidly identifying infections or a contaminated environment. The system combines a few specific fluorescent reagents for identifying immune-cell dysfunction, toxic substances, buildup of microbial antigens or microbial growth, and potential identification of pathogenic microorganisms using a fluorescent microplate reader linked to a laptop computer. The unique feature of the fluorescent-based analysis system is that by using a few specific dyes for cell metabolism, DNA/RNA conjugation, specific enzyme activity, or cell constituents, one can make an immediate, onsite determination of a person's health or of contamination of the environment.

This work was done by Duane L. Pierson of **Johnson Space Center**, *and Raymond P. Stowe and Saroj K. Mishra of KRUG Life Sciences. For further information,* ***write in 84*** *on the TSP Request Card. MSC-22399*

Books & Reports

These reports, studies, and handbooks are available from NASA as Technical Support Packages (TSPs) when a Request Card number is cited; otherwise they are available from the NASA Center for Aerospace Information.

Mathematics and Information Sciences

Telemetry Frame Processor

A report describes a program for creating and editing telemetry frames on a personal computer. The program is menu-driven and can create or edit digital telemetry manually or automatically by occurrence of an event. A stream of telemetric data can be used to test the operation of hardware and software parts of the telemetry-receiving station. The program would be useful in satellite-data-processing facilities like remote-sensing stations.

This work was done by Steve E. Lewis of McDonnell Douglas for **Kennedy Space Center**. *To obtain a copy of the report, "Digital Telemetry (TLM) Frame Building Software (TLMBLDR.EXE)," **write in 1** on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-3017. Refer to KSC-11763.

Linear Prediction of Stationary Sequences of Vectors

A report discusses a direct approach to the linear prediction of a stationary sequence of vectors. It derives a set of equations that constitutes a minimal-order linear predictor. Using this approach, it proposes two specific computationally efficient schemes to predict vectors in a sequence.

The approach taken in this study, inspired by Akaike's coordinate-free realization concepts, is based on simple geometric principles. It involves the suggestion of an explicit coordinate-dependent characterization of the class of all minimal-order linear predictors, in terms of linear transformations on the Hankel covariance matrix associated with the sequence. In contrast with previous approaches, it does not give rise to Riccati or Lyapunov equations. The selection of particular transformation matrices defines specific techniques for the construction of predictors.

This work was done by Yoram Baram of **Ames Research Center**. *To obtain a copy of the report, "Linear Prediction of Stationary Vector Sequences," **write in 22** on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-12352.

Machinery

Human Interfaces in Teleoperations and Virtual Environments

A conference report contains a compilation of papers relating to interactions between humans and machines from the perspectives of (1) telepresence and sensorimotor adaptation, (2) measurement and evaluation of performance, and (3) design principles and predictive models. Topics discussed include neural networks, sensory technology, display, and feedback controls. The report covers the state of the art of remote sensing and control by humans for space or other operations.

This work was done by Nathaniel I. Durlach, Thomas B. Sheridan and Stephen R. Ellis of **Ames Research Center**. *To obtain a copy of the report, "Human Machine Interfaces for Teleoperators and Virtual Environments," **write in 8** on the TSP Request Card. ARC-13302*

Historical Survey of Flight-Testing Accidents

A report presents a study of flight-testing accidents, with emphasis on limitations imposed by human factors. The study covers the history of flight testing from early lighter-than-air craft (including balloons) to vertical take-off airplanes to the space shuttle. The results show that new aircraft and new pilots are not immune to old problems. Inadequacy of pilot skill and training, unintentional errors, and willingness to take unnecessary risks were found to be frequent causes of accidents. One of the lessons learned in the study is that plans designed to cope with otherwise unexpected events can help reduce accidents.

This work was done by Seth B. Anderson of **Ames Research Center**. *To obtain a copy of the report, "Lessons Learned From An Historical Look At Flight Testing," **write in 10** on the TSP Request Card. ARC-13330*

Physical Sciences

Thermodynamic Data for 50 Chemical Elements

A report presents data on the thermodynamic properties of 50 chemical elements, an isotope (deuterium) of one of the elements, and electron gas, all in standard reference states. The data are tabulated as functions of temperature; they are also given in the form of least-squares-fit coefficients of two functional forms for heat capacities (specific heats) at constant pressure (C_p°)in standard states, with constants of integration for enthalpy and entropy.

This work was done by Bonnie J. McBride of **Lewis Research Center**, *Sanford Gordon of Sanford Gordon and Associates, and Martin A. Reno of Heidelberg College. To obtain a copy of the report, "Thermodynamic Data for Fifty Reference Elements," **write in 93** on the TSP Request Card. LEW-15978*

Materials

Stress in a Fiber During Curing of Surrounding Matrix Resin

Experiments were run to determine the variation in tensile stress in a single fiber during curing of a matrix resin that surrounds the fiber. This study is part of an effort to understand the physical mechanisms that affect residual stresses in matrix/fiber composites, with a view

toward optimizing curing cycles (in particular, optimizing the temperature-vs.-time schedules of final cooldowns to ambient temperature) to minimize the residual stresses. The results of these experiments were interpreted as signifying that the primary mechanisms that affect the residual stress in fibers are (1) thermal expansion and contraction and (2) cure shrinkage of the matrix material.

This work was done by Kenneth J. Bowles of **Lewis Research Center** *and Madhu S. Madhukar and Ranga P. Kosuri of the University of Tennessee. No further documentation is available. LEW-15995*

Performance of Perfluoropolyalkylether Lubricant System

Liquid and solid lubricants can both be utilized to reduce friction and wear of bearing surfaces. Liquid lubricants have some advantages which include long life in high cycle applications, high thermal conductivity and low coefficients of friction. Liquid lubricants can also be resupplied as they are consumed. Natural liquid lubricants, while being readily available have some severe shortcomings, e.g., temperature limitations and viscosity fluctuations. The U. S. space program has traditionally used liquid lubricants, but their shortcomings have been a catalyst in the development of a series of synthetic liquid lubricants. Perfluoropolyalkylethers (PFPAE) constitute a class of such fluids. These PFPAE fluids have characteristics that include (1) high thermal oxidative stability, (2) good viscosity-temperature characteristics, (3) good elastohydrodynamic film-forming capabilities, (4) low volatility, and (5) nonflammability. One unfortunate drawback is that PFPAE causes severe metal corrosion and fluid degradation when used in an oxidizing atmosphere.

The reports of interest that are the subject of this brief deal with the synthesis of PFPAE-type liquids and the development of an additive to reduce oxidizing atmosphere degradation. The first report deals with the development of a modified phospha-s-triazine that is hydrolytically stable. When used as an additive to PFPAE, it prevents fluid degradation and metal corrosion in an oxidizing environment. The second report describes the synthesis of four high molecular weight PFPAE-type fluids using a direct fluorination process. The properties and molecular structures are reported in detail. Lubricant performance over a range of conditions is reported in detail.

This work was done by K. Paciorek, S. Masuda, and Wen-Huey Lin of Technolube Products Co. and T. Bierschenk, H. Kawa, T. Juhlke, and R. Lagow of Exfluor Research Corp. for **Lewis Research Center**. *To obtain copies of the reports, "Phospha-S-Triazines of Improved Hydrolytic and Thermal Oxidative Stability" and "Physical and Chemical Properties of Some New Perfluoropolyalkylether Lubricants Prepared by Direct Fluorination,"* ***write in 19*** *on the TSP Request Card. LEW-15603*

Manufacturing/ Fabrication

Composite-Material Propfan Blades for a Wind-Tunnel Model

A report discusses the design and the sequence of operations performed in fabricating a set of graphite-fiber/epoxy-matrix composite propfan blades. The report describes the major phases of fabrication of the blades, including the machining of metal master blades, fabri-

cation of molds from the master blades, cutting of graphite-fiber/epoxy prepreg sheets to form plies, stacking of plies to obtain preforms, assembly of pressure- and suction-side preforms into unitary blade preforms, curing the preforms in molds, final light finishing, and inspection.

This work was done by E. Brian Fite of **Lewis Research Center**. *To obtain a copy of the report, "Fabrication of Composite Propfan Blades for a Cruise Missile Wind Tunnel Model,"* ***write in 9*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-5753. Refer to LEW-16088.

Mechanics

Vacuum Door for Testing a Spacecraft X-Ray Camera

A report describes a vacuum door to provide environmental protection of an x-ray camera aboard a spacecraft, and to provide access to the camera for prelaunch testing. The door seals one side of a chamber and encloses a vacuous or dry gas environment that is needed to protect the camera. To reduce weight and cost and possibly increase reliability, a paraffin actuator is used instead of a motor to open the door. The mechanism can be activated automatically.

This work was done by Donald H. McQueen, Jr., of **Marshall Space Flight Center**. *For further information,* ***write in 82*** *on the TSP Request Card.*
MFS-28963

Radiation Propulsion for Maintaining Orbits

A brief report proposes radiative propulsion systems for maintaining precise orbits of spacecraft. Radiation from electrical heaters would be directed outward by paraboloidal reflectors to produce small forces to oppose the uncontrolled drag and solar-radiative forces that perturb orbits. This would minimize or eliminate the need to fire rocket thrusters to correct orbits. For example, infrared radiated power of only 150 W would compensate for a typical drag force of 0.5 μN. The power would come from surplus electrical energy generated by a solar photovoltaic array or stored in a battery.

This work was done by Robert Richter of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Radiative Propulsion System for Satellites,"* ***write in 20*** *on the TSP Request Card. NPO-19276*

Designing an Adaptor To Connect Rocket Stages

A report describes design of a lightweight truss structure to serve as an adaptor to connect two rocket stages, subject to a stringent requirement to minimize cost. The larger stage is a Centaur rocket, on which are provided eight attachment points arranged in a circle 111.77 in. (283.90 cm) in diameter. The smaller stage is a Thiokol Star 48b rocket, which includes a round attachment flange, 45 in. (114.3 cm) in diameter. For mating with the attachment flange, the design provides for grooved slats at the upper ends of the struts. The weight of the truss structure would be less than that of the corresponding stiffened conical shell.

This work was done by Lisa L. Gann and Michael T. Hicks of Harvey Mudd College for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Pluto Fast Flyby Probe:*

Interstage Adaptor Designs for Thiokol 48b and Centaur and for Thiokol 48b and Thiokol 27 Stages," ***write in 69*** *on the TSP Request Card. NPO-19468*

Electronic Systems

Evaluation of Vibration-Monitoring Gear-Diagnostic System

A report describes an experimental evaluation of a commercial electronic system designed to monitor the vibration signal from an accelerometer on a gearbox to detect vibrations indicative of damage to gears. The system includes a signal-conditioning subsystem and a personal computer in which an analog-to-digital converter has been installed. The results of the experiment showed that the system is fairly effective in detecting surface fatigue pits on spur-gear teeth.

This work was done by Dennis P. Townsend and James J. Zakrajsek of **Lewis Research Center**. *To obtain a copy of the report, "Evaluation of a Vibration Diagnostic System for the Detection of Spur Gear Pitting Failures,"* ***write in 61*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-5753 . Refer to LEW-16091.

Comparison of Full-Spectrum and Complex-Symbol Combining

A report presents a theoretical study of the anticipated performances of two methods of combining S-band signals from the Galileo spacecraft received in multiple antennas of NASA's Deep Space Network (DSN). The signal transmitted by the spacecraft consists of a binary data signal phase-modulated onto a square-wave subcarrier that is, in turn, amplitude-modulated onto an S-band carrier.

This work was done by Samson Million, Biren Shah, and Sami Hinedi of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "A Comparison of Full-Spectrum and Complex-Symbol Combining Techniques for the Galileo S-Band Mission,"* ***write in 11*** *on the TSP Request Card. NPO-19392*

Electronic Components and Circuits

Developing Low-Noise GaAs JFETs for Cryogenic Operation

A report discusses aspects of an effort to develop low-noise, low-gate-leakage gallium arsenide-based junction field-effect transistors (JFETs) for operation at a temperature of about 4 K as readout amplifiers and multiplexing devices for infrared-imaging devices. These transistors are needed to replace silicon transistors, which are relatively noisy at 4 K. The report briefly discusses the basic physical principles of JFETs and describes a continuing process of optimization of the designs of GaAs JFETs for cryogenic operation.

This work was done by Thomas J. Cunningham of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Gallium Arsenide Junction Field-Effect Transistors for Deep Cryogenic Applications,"* ***write in 72*** *on the TSP Request Card. NPO-19417*

New on the Market

Product of the Month

Integrated Computing Engines Inc., Cambridge, MA, has introduced the Desktop RealTime Engine™ **computing system** combining the speed of a supercomputer with the economy of a desktop workstation. The "superstations" work with existing PC and workstation hosts, and are the size of a small briefcase. Designed for simulation, graphics, signal processing, imaging, and neural network applications, the systems incorporate Analog Devices' ADSP-21060 Sharc chips. They transfer data at 80 Mbps via cable to an EISA PC running OS/2, Windows NT, or Digital UNIX. The PC provides the operating system and user interface, and also can supply disk storage and backup. Prices are $99,500 for a 40 MHz system and $50,000 for a 33 MHz system.

For More Information Write In No. 700

Fluke Corp., Everett, WA, has announced the 100 MHz Model 105 ScopeMeter® Series II handheld **digital oscilloscope/multimeter** for troubleshooting high frequency signals. The device can be switched between meter and scope functions, providing numeric readings and a waveform display of the measured signal. More than 30 common measurements can be accessed. Flukeview software stores sample waveforms and builds an historical database.

For More Information Write In No. 701

Series BOP 100- to 400-watt, four-quadrant **power supplies** from KEPCO Inc., Flushing, NY, provide voltage for test and simulation, and feature high gain and wide bandwidth to function as operational amplifiers. Output can be controlled linearly through zero with no polarity switching, and separate control circuits are provided for voltage and current. Optional digital displays and talk-listen digital cards are available.

For More Information Write In No. 702

The UniForce **pressure sensors** from Force Imaging Technologies, Chicago, IL, are 0.003" thick and produced on a flexible substrate material for use in manufacturing component assembly and equipment and product condition diagnosis. They measure contact force in real time by changing resistance as a function of force applied to the sensor's surface.

For More Information Write In No. 703

Interpoint Corp., Redmond, WA, has introduced the MHV Series of 15-watt **DC-DC converters** featuring low output noise and an input range of 16 to 50 Vdc. Available in a triple output configuration, the converters feature surge protection to 80 V for 120 milliseconds, output power of 10 watts from main output and 5 watts from auxiliary outputs, and an operating temperature range from -55° C to 125° C.

For More Information Write In No. 704

The YS Series Megatorque® **motor system** from NSK Corp., Bloomingdale, IL, provides high torque at low speeds. The closed-loop control system has repeatability of ±2.1 seconds with up to 177 ft/lb of torque at a speed of 3 rps. It comes with a direct drive motor, ES servo driver, and cables. The system can be used as a rotary actuator for robots, transfer systems, and chamfering machines, or as a rotary indexer for assembly machines, measuring instruments, and machining centers.

For More Information Write In No. 705

Mirus Industries Corp., Santa Clara, CA, has introduced a **desktop film recorder** that makes 35 mm color slides of text, charts, 3D models, CAD drawings, and other images created on Macintosh or PC platforms. The 5K resolution FilmPrinter Galleria™ uses 36-bit color resolution and supports most presentation, drawing, and design software packages. Features include film brightness, contrast, and color balance control; automatic camera; electronic spot filtering; and double-hit exposure technology.

For More Information Write In No. 706

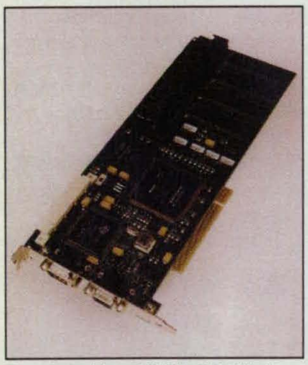
New on the Market

Advanced Motion Controls Inc., Princeton, WI, has introduced the AMC-5000DSP digital signal processing **motion controller card** for the IBM-compatible PC platform. A 40 MHz DSP CPU allows execution of 2000 programming steps/sec. or 1000 coordinated steps/sec. The system can control brush DC, brushless DC, AC induction, switched reluctance, and stepping motors.

For More Information Write In No. 718

CheckSum Inc., Arlington, WA, has announced the Model TR-8 **manufacturing defects analyzer** which uses Hewlett-Packard TestJet technology to detect SMT open connections to bussed devices such as integrated circuits and connectors. It is compatible with the company's TR-6 functional test system and mechanical, pneumatic, and vacuum fixturing systems. Prices start under $15,000 for 400-point configurations with controller, MDA electronics, software, and fixture receiver.

For More Information Write In No. 708



The Sapphire 2SX™ 3D/Windows **graphics accelerator card** from Fujitsu Microelectronics' Graphics Division, San Jose, CA, offers 2D/3D graphics capabilities for PC, CAD, design automation, scientific visualization, and simulation applications. Users can interactively model, rotate, render, and explode 3D solids and 2D wireframe models. A display system enables multiple cards to be connected for increased rendering speed.

For More Information Write In No. 709

Technical Fibre Products, Slate Hill, NY, has introduced the Optimat series of **nonwoven materials** made from carbon, metal-coated, glass, polyester, quartz, and silicon carbide fibers. Applications include printed circuit board bases, interior surface finishing, electrostatic discharge protection, avionics shielding, deicing, and other areas requiring resistivity, conformability, and fiber blending. Fibers can be bonded with organic binders to improve end-product strength, chemical resistance, and flexibility.

For More Information Write In No. 710

The SLM M4-704X512 nematic active matrix liquid crystal **spatial light modulator** from WAH-III Technology Corp., Novato, CA, includes software, cables, electronics, and a power supply. Designed for use in projection systems, head-mounted displays, holographic data storage, and optical computing, the system can be integrated into solid- or air-spaced systems. IBM-compatible software allows downloading of patterns or images.

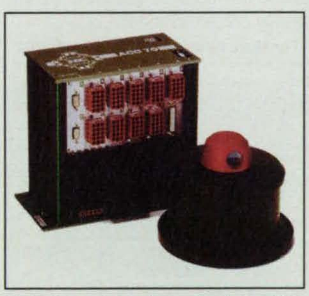
For More Information Write In No. 711

The PXS5-722SA **portable x-ray source** from Kevex X-Ray Inc., Scotts Valley, CA, features a microfocus side window x-ray tube, radiation shielding, and a self-contained, high-voltage power supply. Weighing 7 lbs., the device allows users to get close coupling of the x-ray source to the object, enabling direct x-ray magnification for inspection of microelectronics and other components. The device operates continuously at a maximum of 7 watts and a target voltage to 70kV.

For More Information Write In No. 712

Imagraph Corp., Chelmsford, MA, has introduced the IMASCAN/Precision **video frame grabber**. It digitizes color or monochrome video sources under Windows-based software for storage on disk, quality enhancement, recognition, and live viewing on a VGA display. Six video input channels are available for various configurations.

For More Information Write In No. 714



NDC Automation Inc., Charlotte, NC, has announced a **laser navigation system** that uses laser beams to direct automatic guided vehicles (AGVs) in critical environments such as cleanrooms, and in manufacturing and assembly areas. Using reflective-tape targets with known positions, the laser navigation head on the AGV sends out a sweeping, invisible infrared beam that scans the operating area. The vehicle's on-board computer calculates its position within millimeters.

For More Information Write In No. 719

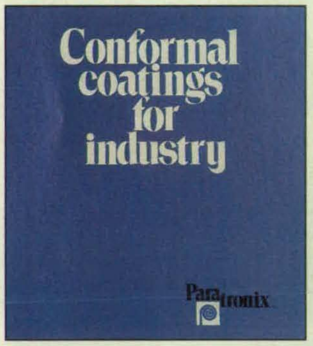
New Literature

Omega Engineering, Stamford, CT, offers a set of seven books illustrating **process measurement and control** devices. They cover temperature, pressure and strain, flow and level, data acquisition, pH and conductivity, electric heaters, and environmental issues.

For More Information Write In No. 750

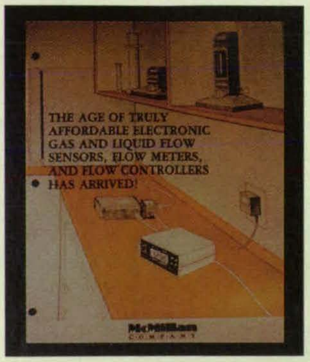
A 20-page brochure from DSM Engineering Plastics, Evansville, IN, describes **wear- and friction-resistant thermoplastics.** Materials selection information and property data for 56 grades are included.

For More Information Write In No. 751



A six-page brochure on Parylene **conformal coatings** from Paratronix, Attleboro, MA, describes applications in microelectronics, hybrid circuits, medical devices, circuit board coatings, and corrosion-resistant coatings. The coatings provide dielectric strength and encapsulation of residue.

For More Information Write In No. 752

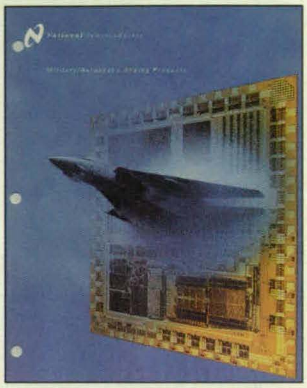


McMillan Co., Georgetown, TX, offers a four-page brochure of **electronic gas and liquid flow measurement** equipment including flow sensors, flow meters, and flow controllers with flow rates from 13 ml/min. to 500 L/min.

For More Information Write In No. 753

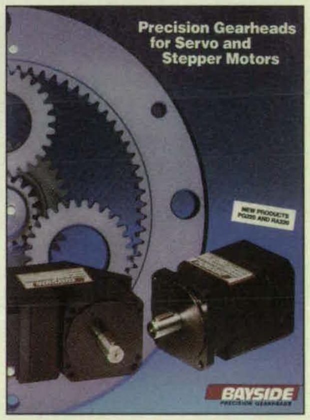
A 40-page catalog of Superior SLO-SYN® **servo amplifiers, motors, and power supplies** is available from Warner Electric Linear Motion and Electronics Division, Bristol, CT. It features specifications, dimensional diagrams, and performance characteristics.

For More Information Write In No. 754



National Semiconductor, Santa Clara, CA, offers a 16-page catalog of **military/aerospace analog products**, listing high-performance amplifiers and buffers, comparators, positive and negative voltage and linear regulators, voltage references, switching regulators, and data acquisition.

For More Information Write In No. 755



A 22-page catalog of **precision gearheads** for servo and stepper motors from Bayside Controls Inc., Port Washington, NY, contains photographs, cut-away diagrams, and statistics and specifications for planetary, NEMA, and right-angle NEMA gearheads, and mounting and ordering information.

For More Information Write In No. 756

The *U.S. Space Directory*, a civil, military, and commercial **space industry reference** from Space Publications, Bethesda, MD, includes profiles of organizations in major industry sectors involved with launch vehicles, satellites, remote sensing, ground stations, technical support, microgravity hardware, and research and engineering.

For More Information Write In No. 757

IOTech Inc., Cleveland, OH, has released its 1995 **IEEE 488 & data acquisition** catalog highlighting the company's new PCMCIA A/D cards for notebook PCs; DSP-based portable multichannel digitizer for desktop and notebook PCs; expanded series of DBK signal conditioning options; and portable thermocouple and voltage measurement systems.

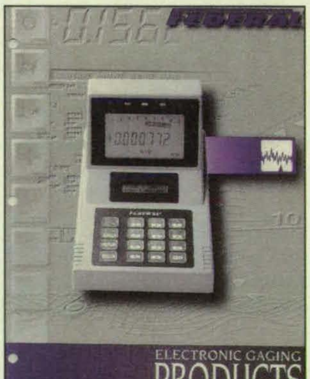
For More Information Write In No. 758

A six-page brochure from Polymer Corp., Reading, PA, describes new Nylatron® GSM **blue cast nylon** for use in high load and low velocity bearing applications. Included are typical applications and relative part life, limiting PV, and compressive strength comparison charts.

For More Information Write In No. 759

Sector Systems Co. Inc., Marblehead, MA, offers an eight-page **engineering PC shareware** catalog of over 150 disks of AUTOCAD symbols and utilities for electronic, mechanical, and architectural engineers, and hundreds of programs for aerospace, electronic, HVAC, maintenance, mechanical, numerical control, production, and quality control engineers.

For More Information Write In No. 760



Federal Products Co., Providence, RI, has published its 20-page catalog of **electronic gauging instruments**, with a selection of gauge heads, stands, accessories, and the company's cost-effective Series 832 gauging amplifier.

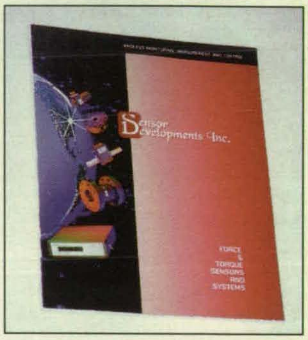
For More Information Write In No. 761

A 16-page product and properties guide to Crastin **PBT thermoplastic polyester resins** from DuPont Engineering Polymers, Wilmington, DE, describes the mechanical, thermal, and electrical properties of 21 grades for a range of automotive, electrical/electronics, and other applications.

For More Information Write In No. 762

A 20-page brochure from Rolled Alloys, Temperance, MI, details chemistry and performance parameters of ten **aircraft and aerospace alloys** in sheet, plate, and bar forms. Included are RA625, RA718, RA X, RA188, A-286, L-605, Rene® 41, Waspaloy, and Greek Ascoloy.

For More Information Write In No. 763



Sensor Developments Inc., Orion, MI, has introduced its new 100-page **force and torque sensor** catalog, with product information and specifications on torque, force, automotive, and multicomponent sensors; pressure; slip rings; instrumentation; accessories; and quality assurance.

For More Information Write In No. 764

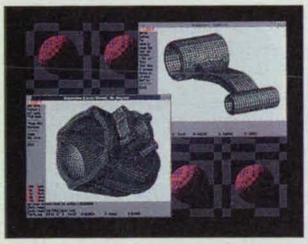
A 288-page *1995 Product Handbook* **data acquisition and imaging products** catalog from Data Translation, Marlboro, MA, highlights software solutions under DT-Open Layers®, new PCI local bus solutions, PC Card-EZ for portable and battery-powered data acquisition applications, the updated GLOBAL LAB® Image family of imaging solutions, and a new Frame Grabber SDK for C programmers.

For More Information Write In No. 765

New on Disk

O-Matrix® 2.1 for Windows™ **interactive analysis and visualization software** from Harmonic Software Inc., Seattle, WA, provides analysis and graphics capabilities, an integrated debugger, a profiler, a full-screen editor, and matrix-oriented interpreted language. The program enables development of applications in mathematics, statistics, and scientific analysis. The software costs $395.

For More Information Write In No. 740



Algor Inc., Pittsburgh, PA, has released Houdini 3.0 **finite element modeling software** with automatic eight-node brick meshing and processing of solid models, 3D plate/shell models, and 3D finite element models from CAD and FEA sources that use tetrahedral elements. Using STL or IGES files, the program can be used for solid models created in most CAD systems. The PC program costs $2000; the UNIX version is $4000.

For More Information Write In No. 741

Intelligent Light, Lyndhurst, NJ, has announced version 5.1 of Fieldview **CFD post-processor software**, featuring an interactive calculator, surface integration, curved surface plotting, and new visualization tools. The update adds features to aid in 3D transient data analysis, enabling users to study results on a desktop computer. The program is available on UNIX platforms. Prices begin at $8500 for commercial customers; university licenses are $1000.

For More Information Write In No. 742

Stylus 2.2 for Windows **Russian/English translation software** from Smart Link Corp., Newport Beach, CA, translates Russian to English or English to Russian at up to one page per second. Specialized dictionaries allow functional translations in areas such as engineering, aerospace, computing, and mathematics. The Russian/English and English/Russian programs cost $350 each; a bi-directional program costs $500.

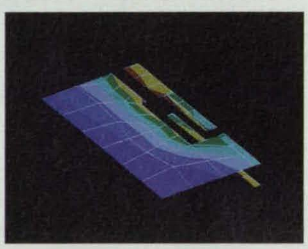
For More Information Write in No. 743

Datum Inc., Bancomm Div., San Jose, CA, has announced TYMSYNC™ **workstation synchronization software**. The system synchronizes Netware 3.x workstations to a source of Universal Time Coordinated (UTC) standard international time. The program continuously synchronizes workstations to within ±100 milliseconds. It operates as a file server Netware Loadable Module and a Terminate and Stay Resident in each workstation. Prices start at $195 for 10 users.

For More Information Write In No. 744

Computer Design Inc., Grand Rapids, MI, offers CAD V™ DesignConcept™ **CAD visualizer software** for users working with CAD data from modelers supporting IGES surface entities. The program allows visualization of CAD models earlier in the design cycle with textures and materials that will be used in product development and manufacturing. CAD data is combined with dimensionally accurate materials and production-ready graphics. The software costs $15,000.

For More Information Write In No. 745



MicroWaveLab **3D electromagnetic analysis software** from the MacNeal-Schwendler Corp., Los Angeles, CA, is used for high-frequency applications such as microstrip and waveguide components, and resonators. Using edge elements and absorbing boundaries, the program calculates network parameters such as scattering matrices, port impedances, and propagation constants. It incorporates ACIS solids geometry and automated meshing capabilities. Results can be displayed in various formats, and converted into formats for complementary tools such as Super-Compact and Touchstone.

For More Information Write In No. 746

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